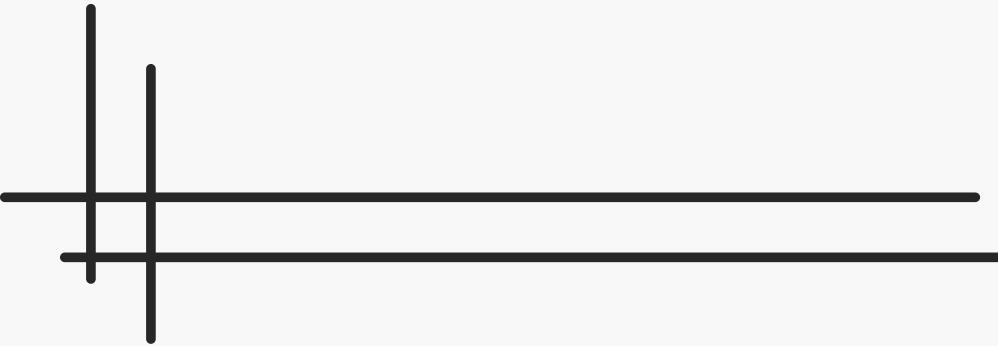




Geographic
Information System

Raster Data

05 DEC, 2025



Tzu-Cheng Chang (2025)

Content

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Intro to Raster

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03

Raster Operation

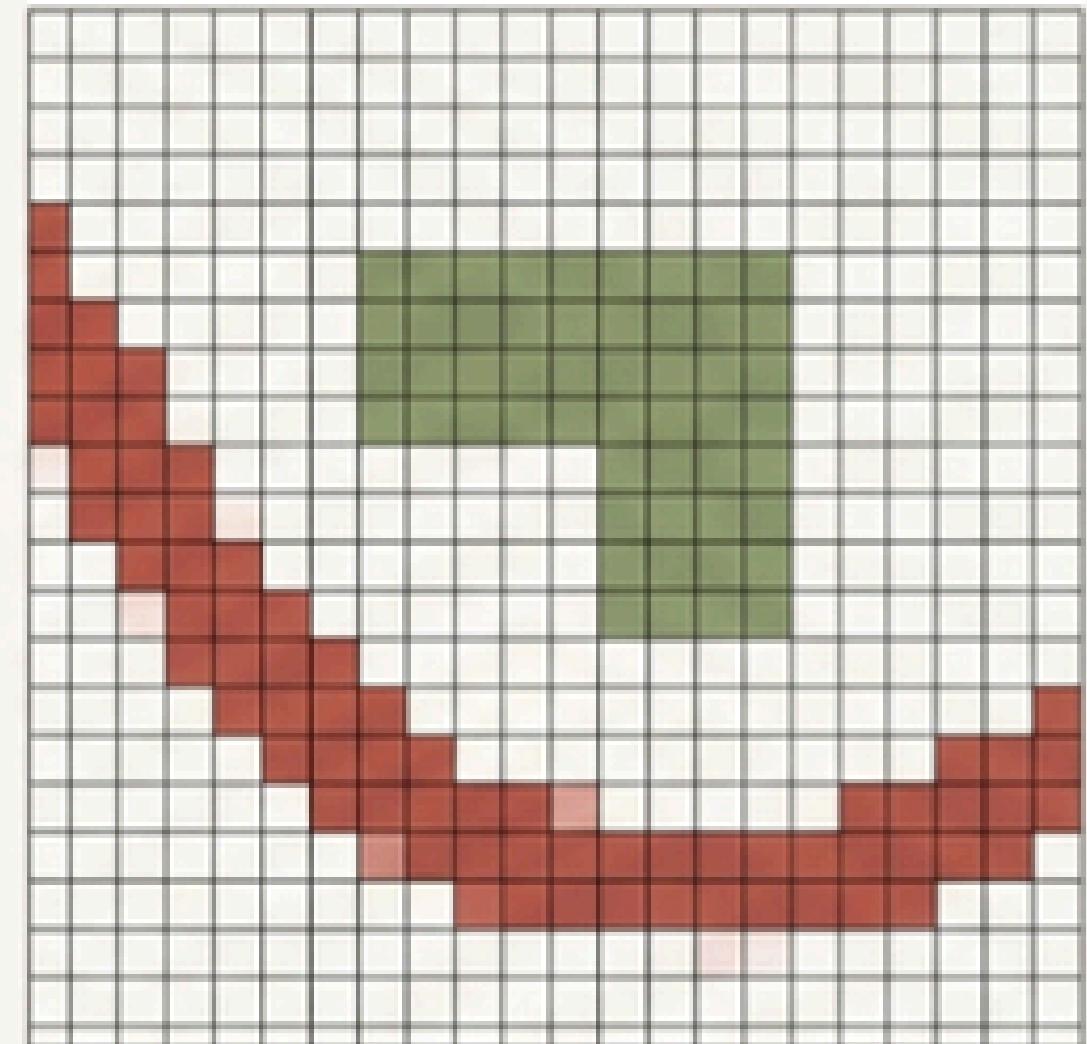
What is a Raster?



Real World



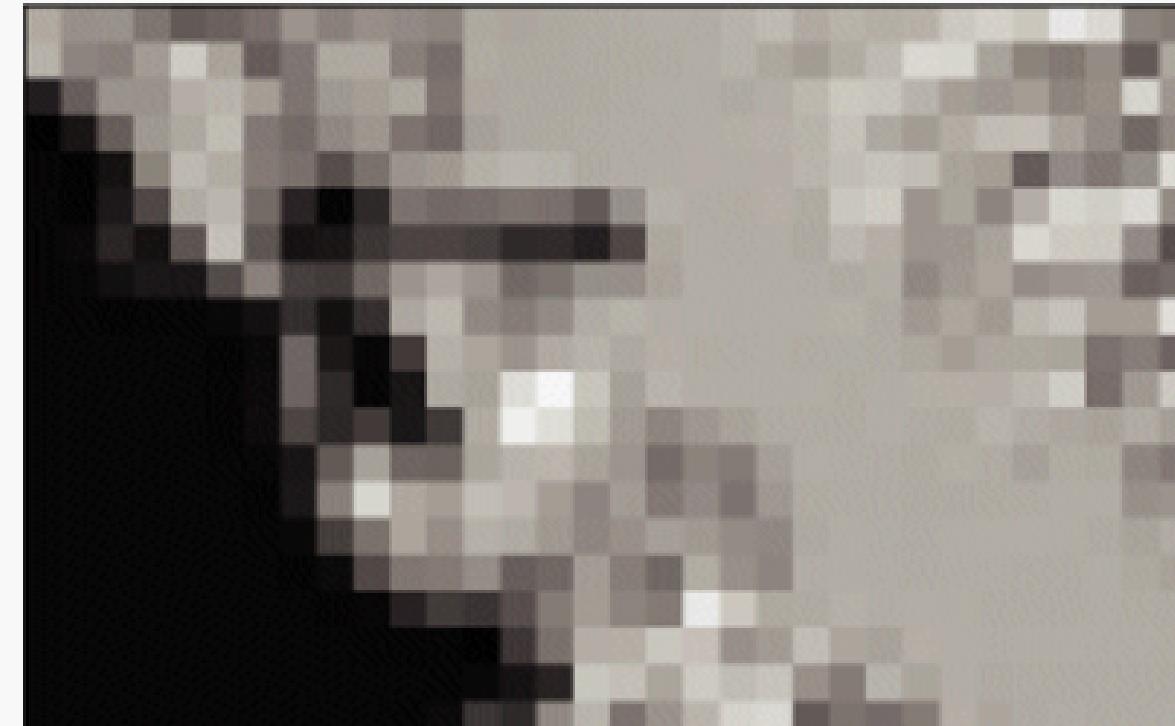
Vector



Raster

What is a Raster?

- A raster consists of a matrix of cells (or pixels) organized into rows and columns.
- Each cell contains a value representing information. E.g. Temperature, Elevation.
- Rasters are digital aerial photo, imagery from satellites, digital pictures, or scanned maps.

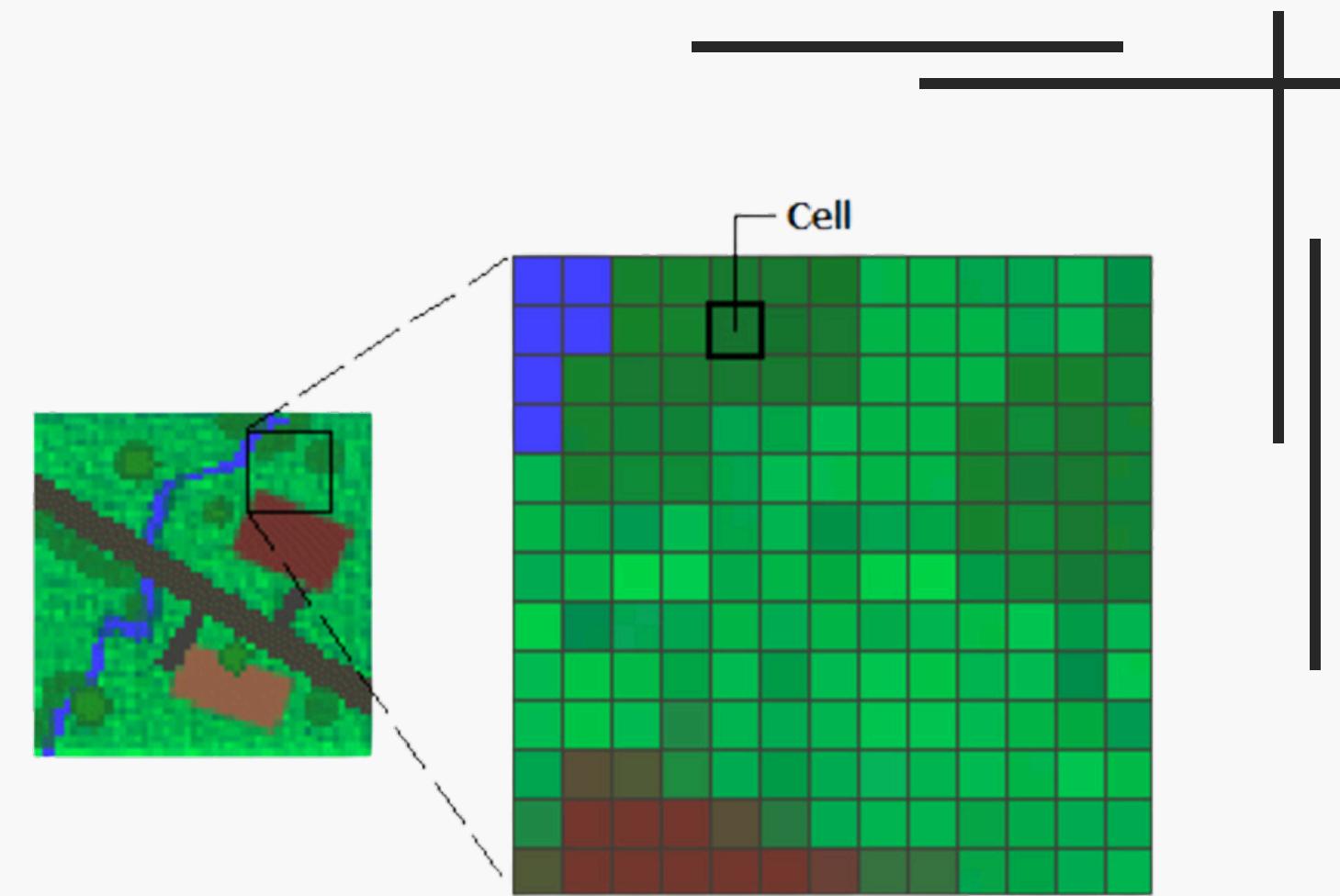


Raster Properties

3 Resolutions

- **Spatial Resolution - Clarity of detail**
- **Radiometric Resolution - Depth of information**
- **Spectral Resolution - Types of information captured**

Raster Properties



■ Cell Size

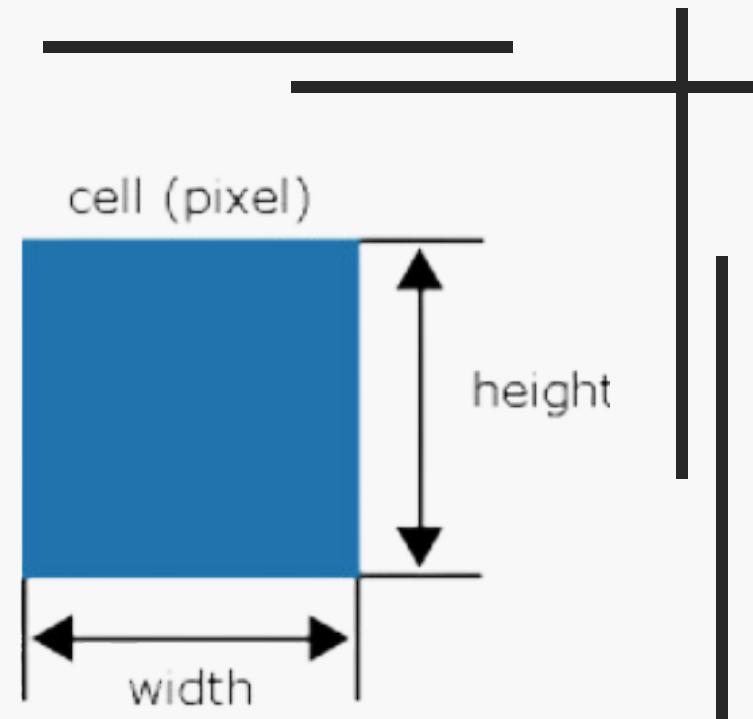
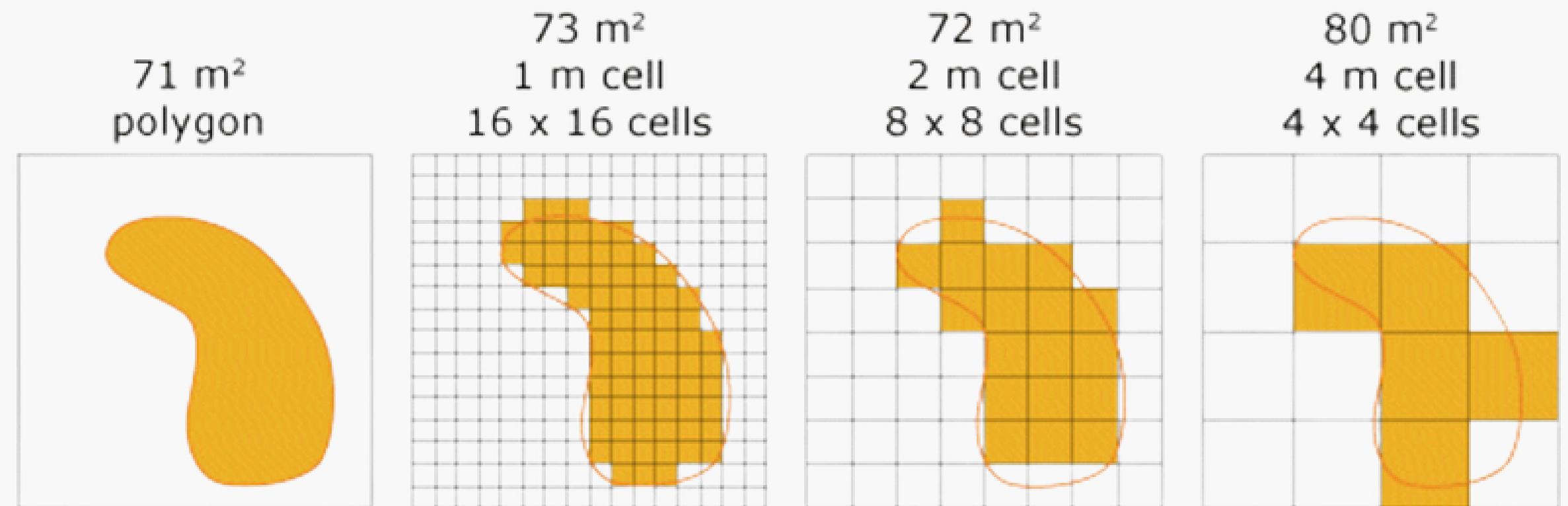
- **Spatial resolution is defined by the ground area covered by a pixel.**
 - Smaller cells capture more detail and create a finer, more realistic image. However, this comes at the cost of significantly larger file sizes. The choice of resolution is a trade-off between detail and performance.

■ Bits Depth

■ Bands

Spatial Resolution

- Cell Size
- Bits Depth
- Bands



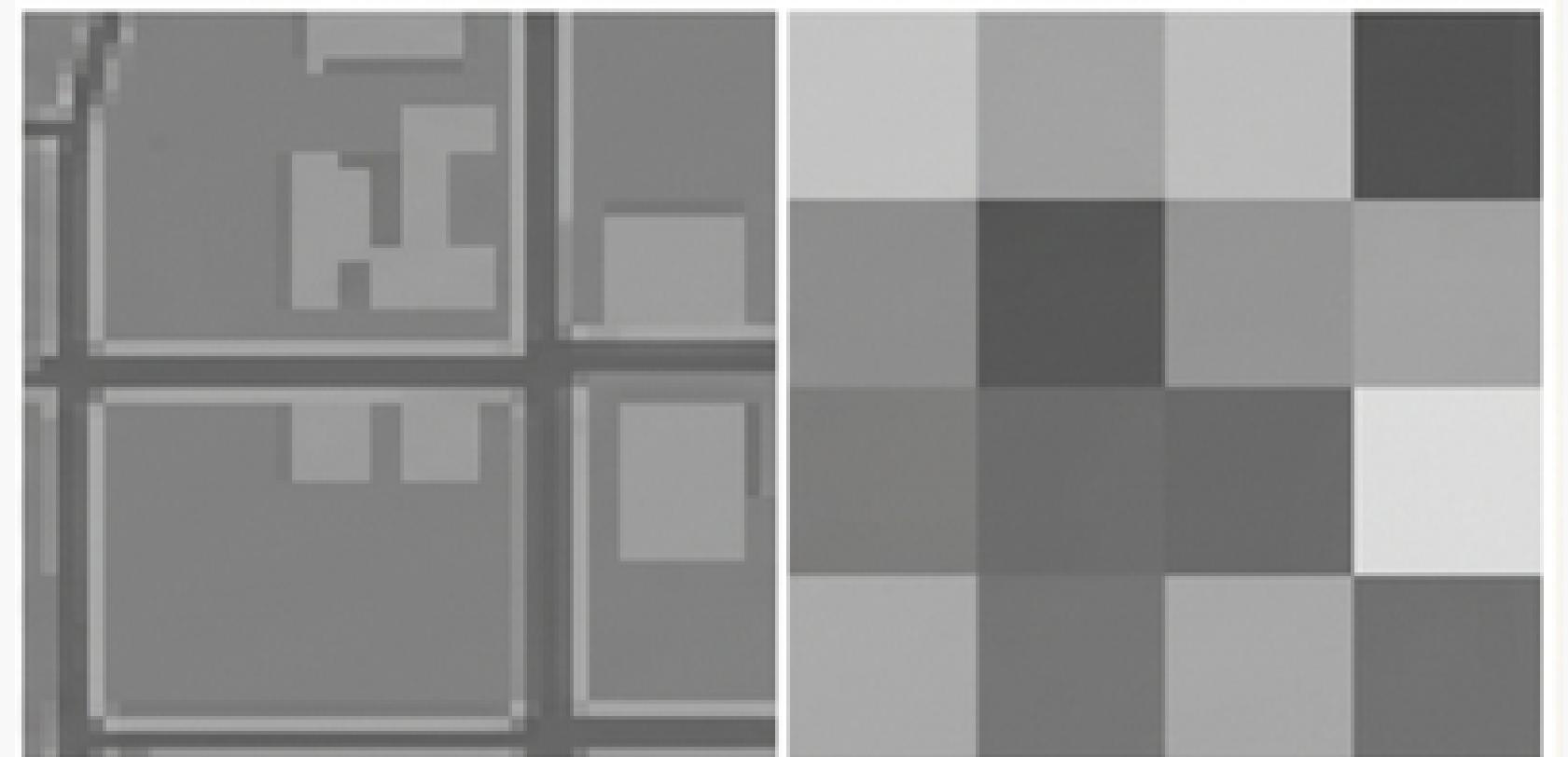
Spatial Resolution

- Cell Size
- Bits Depth
- Bands



(a) 1m

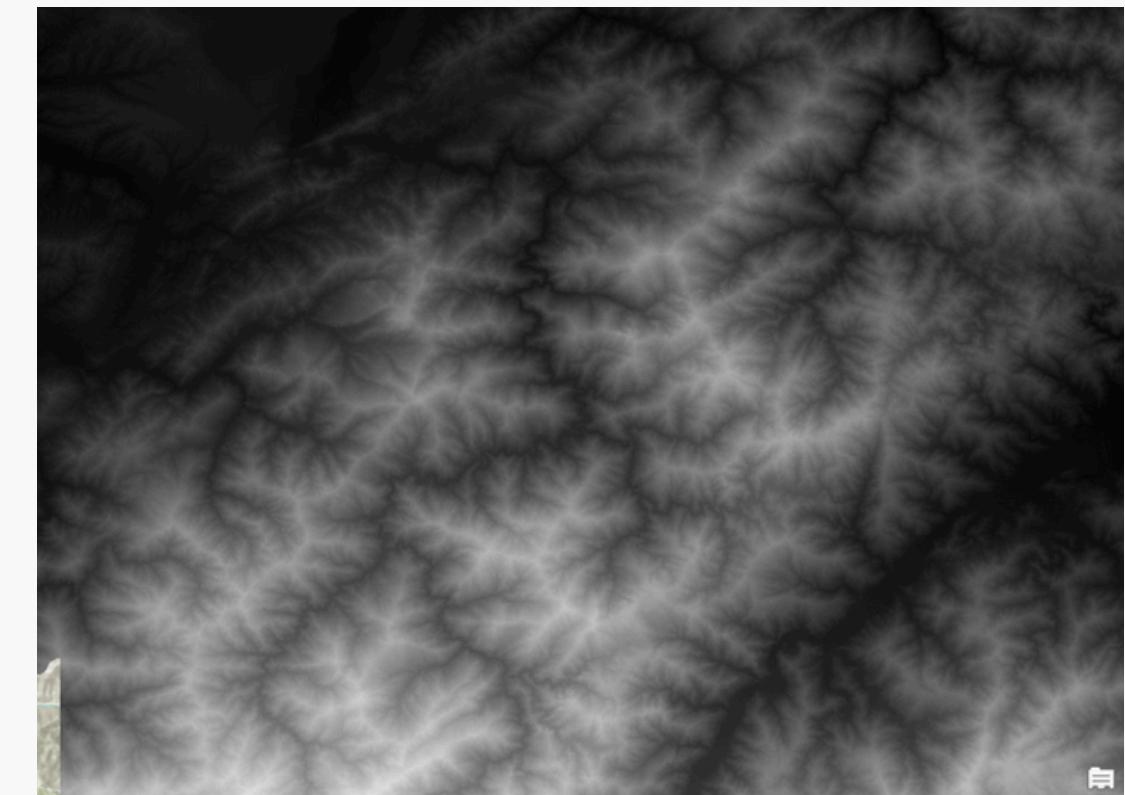
(b) 10m



(c) 30m

(d) 250m

Radiometric Resolution



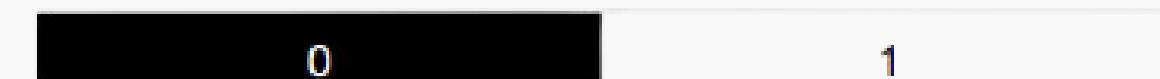
- Cell Size
- Bits Depth
 - is defined by the range of values a cell can store.
 - Higher bit depth allows a cell to store a wider range of values, enabling it to capture more subtle variations in the measured phenomenon (e.g., surface temperature, brightness).
- Bands

Radiometric Resolution

- Cell Size
- Bits Depth
- Bands

2^n

1 bit (binary)



2 bits



4 bits



8 bits



16 bits



Radiometric Resolution

- Cell Size
- Bits Depth
- Bands



8 bits (256 levels)

4 bits (16 levels)



2 bits (4 levels)

1 bit (2 levels)

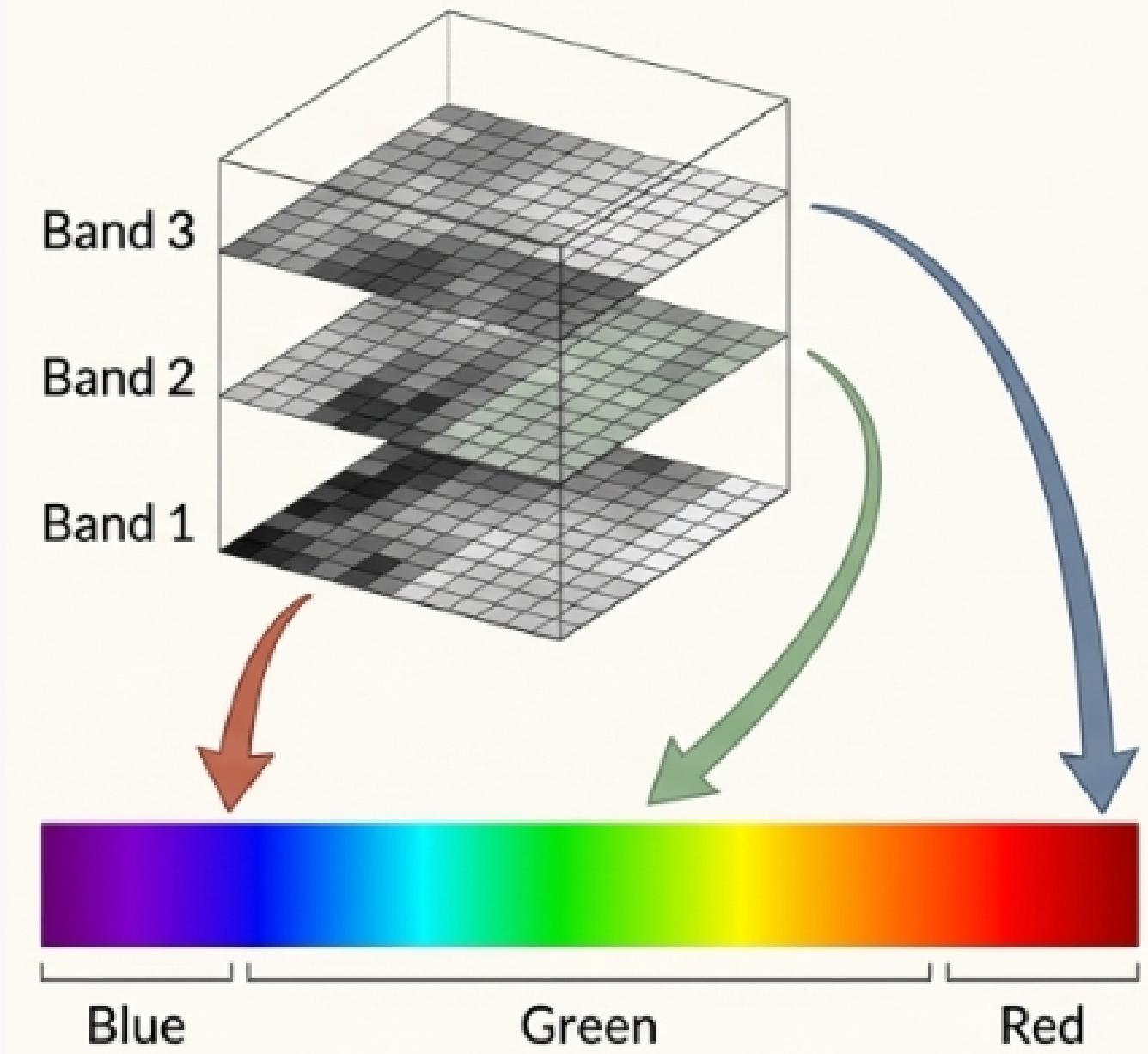
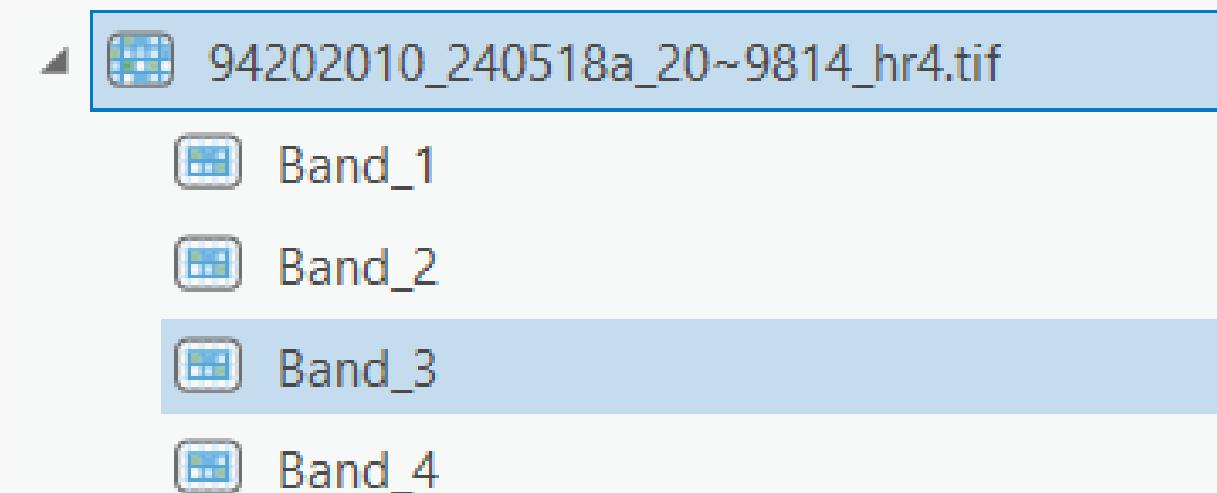
Spectral Resolution



- Cell Size
- Bits Depth
- Bands
 - Spectral resolution is defined by the number and width of spectral bands a sensor can capture. Each band records energy from a specific portion of the electromagnetic spectrum.

Spectral Resolution

- Cell Size
- Bits Depth
- Bands



Spectral Resolution

■ Cell Size

■ Bits Depth

■ Bands

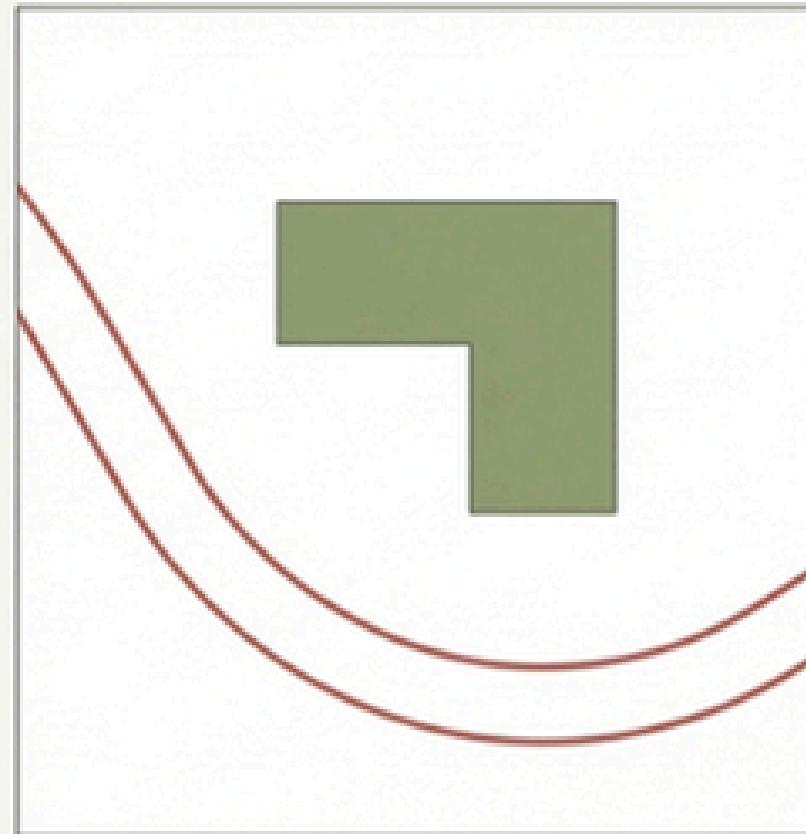
	Channel	Landsat-8 OLI band (nms)	Center wavelength (nms)	Spatial resolution (m)
	Coastal/Aerosol	Band 1 (433–453)	443	30
	Blue	Band 2 (450–515)	483	30
	Green	Band 3 (525–600)	560	30
	Red	Band 4 (630–680)	660	30
	NIR	Band 5 (845–885)	865	30
	SWIR 1	Band 6 (1560–1660)	1650	30
	SWIR2	Band 7 (2100–2300)	2220	30
	Panchromatic	Band 8 (500–680)	640	15
	Cirrus	Band 9 (1360–1390)	1375	30

Feature vs. Raster

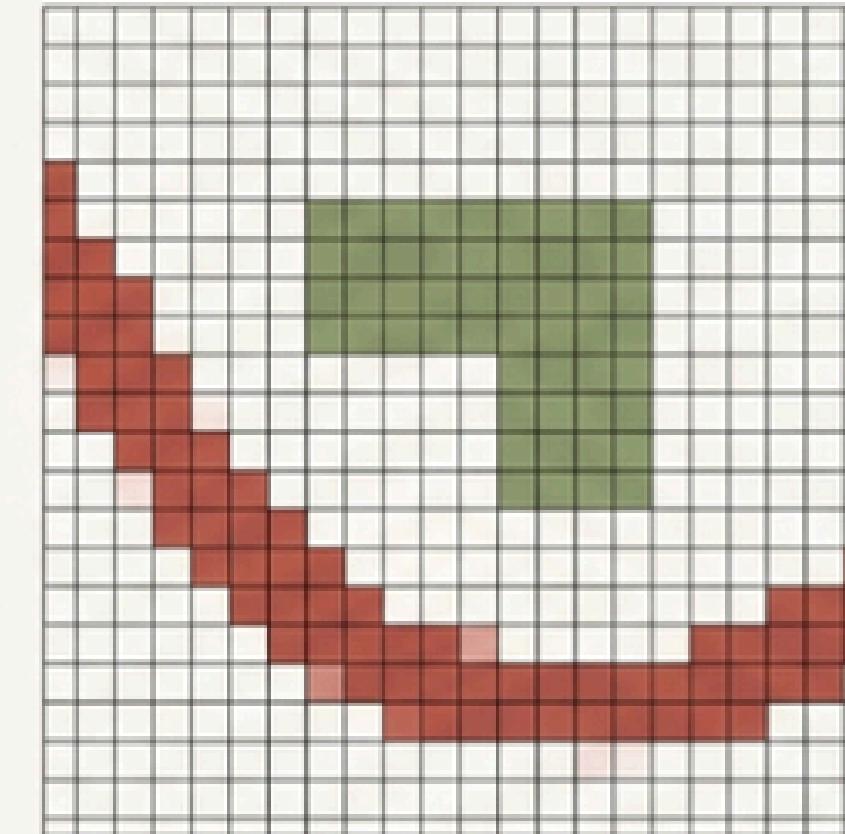
Raster data represents the world as a continuous surface, divided into a matrix of cells, or pixels. Each cell holds a single value representing information like elevation or temperature.



Real World



Vector



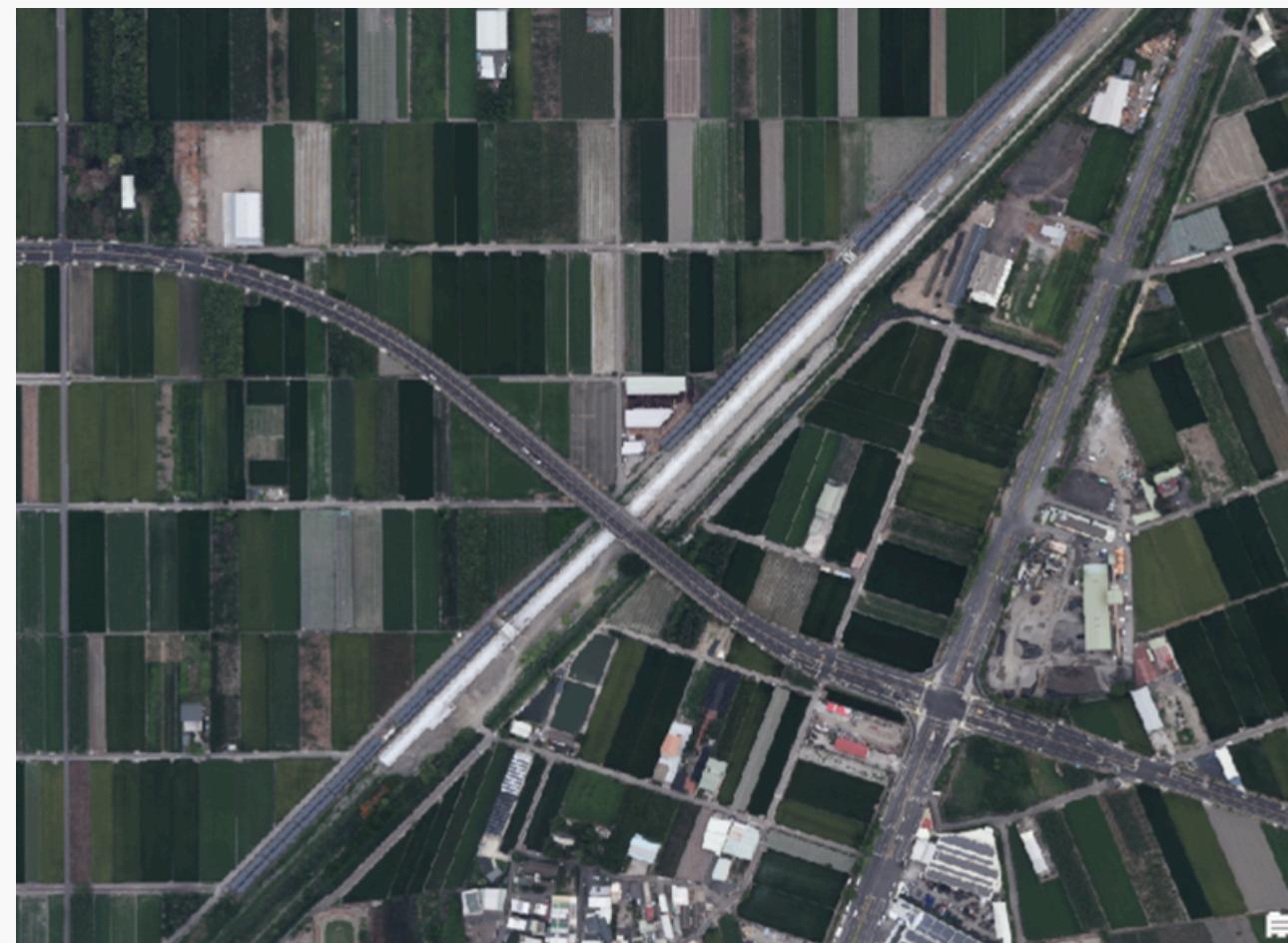
Raster

Raster Application

a. DEM / DTM



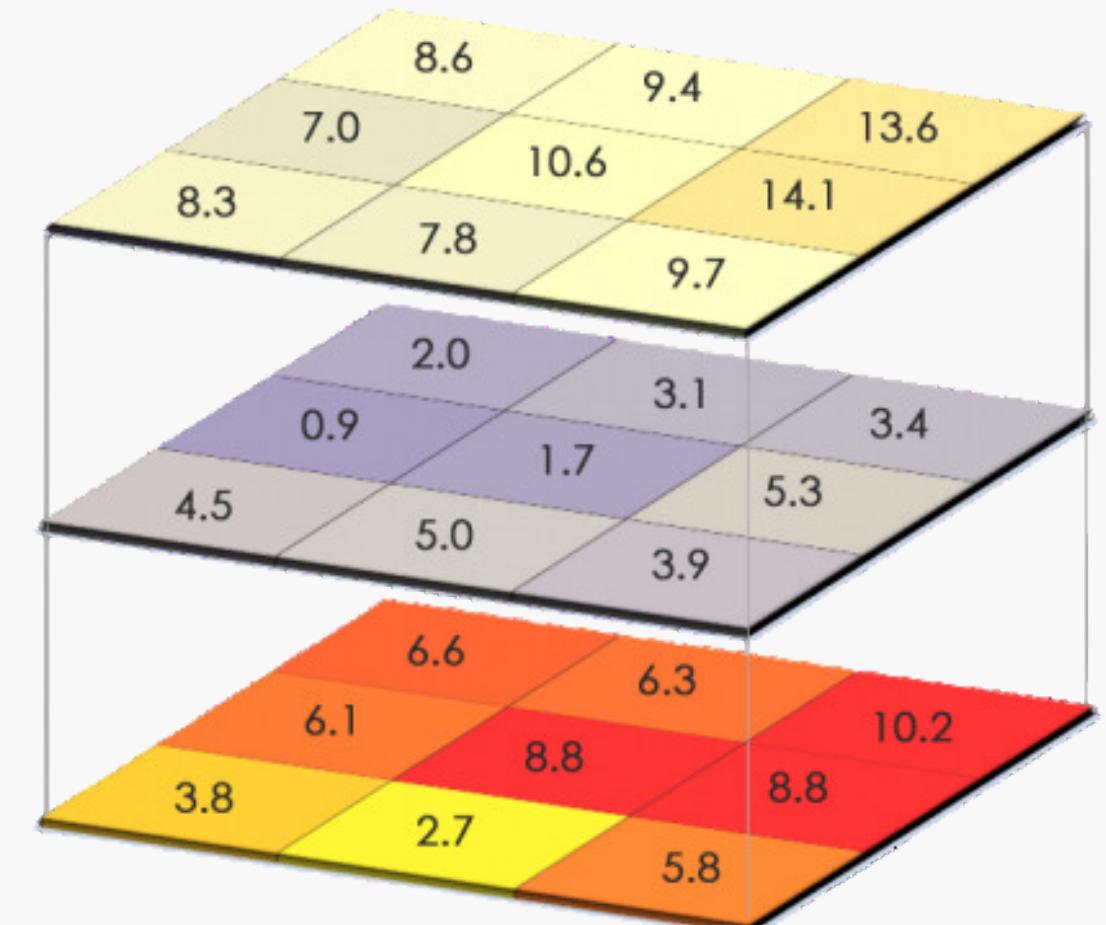
b. Imagery



Map Algebra

- Map algebra basically involves doing math with maps.
- NODATA / Null are not belongs to values.
- It can be processed between different band / raster layers.
- In Map Algebra, coordinate system matters!

Before doing Map Algebra, must make sure features have correct coordinate system.

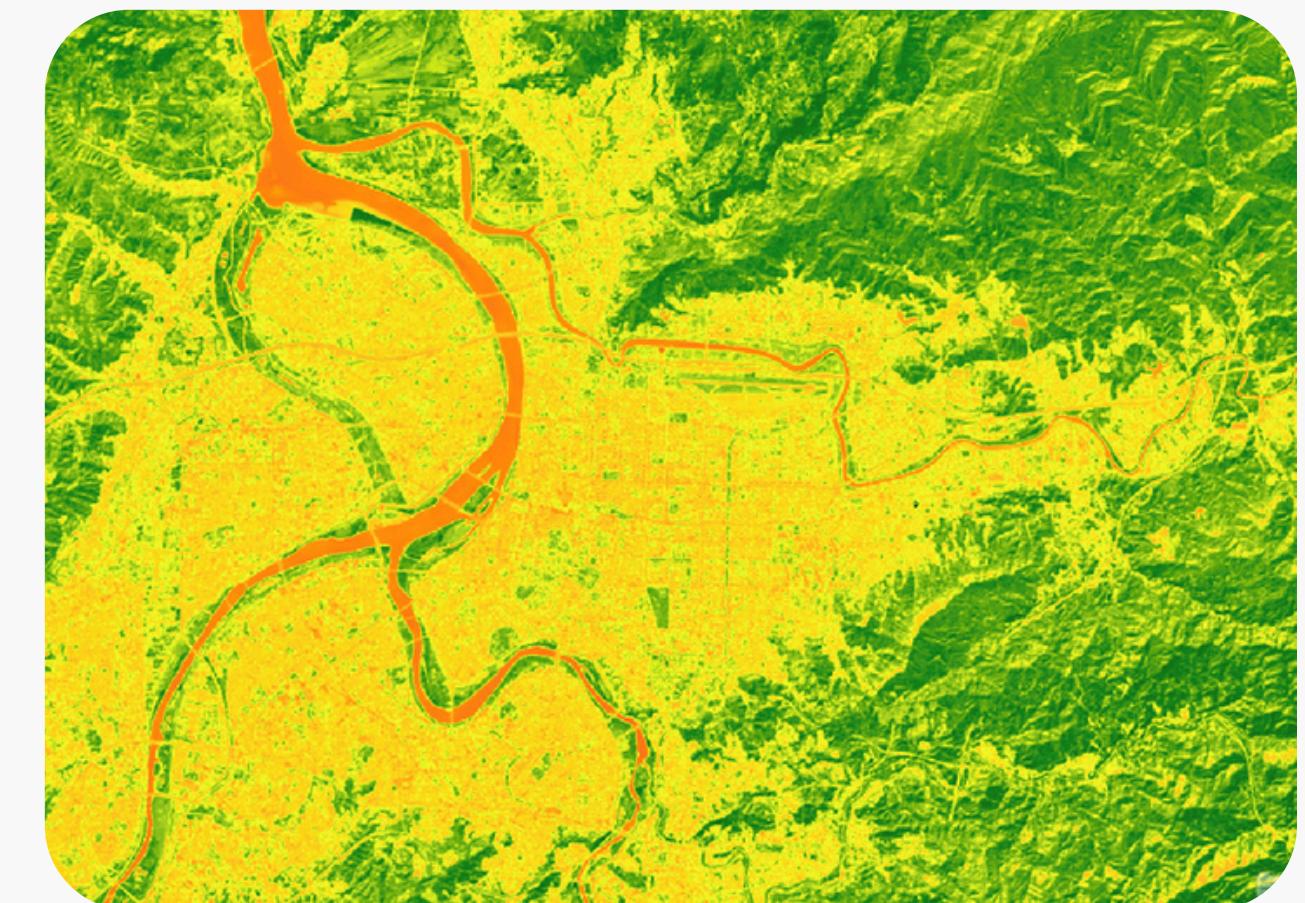


NDVI

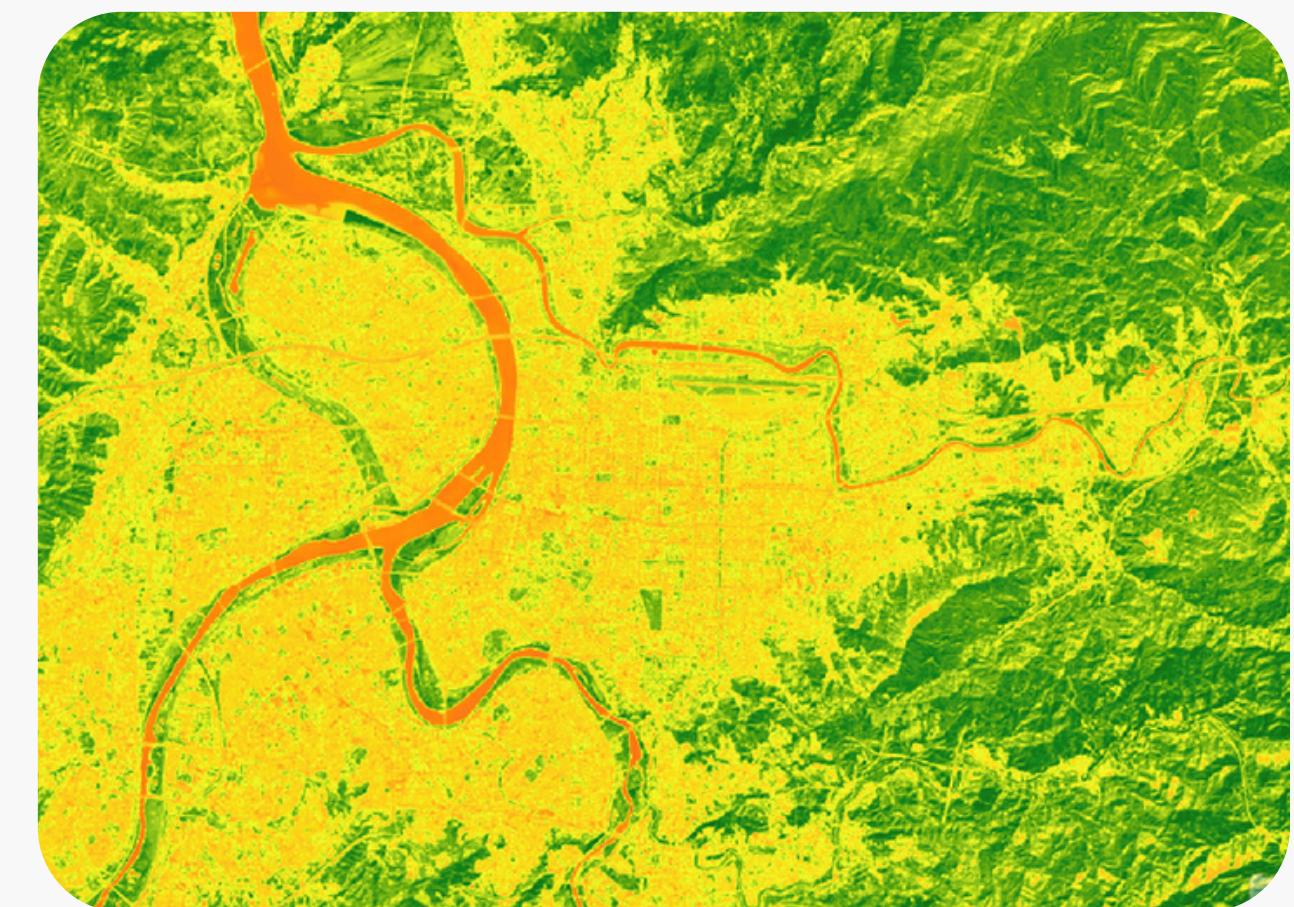
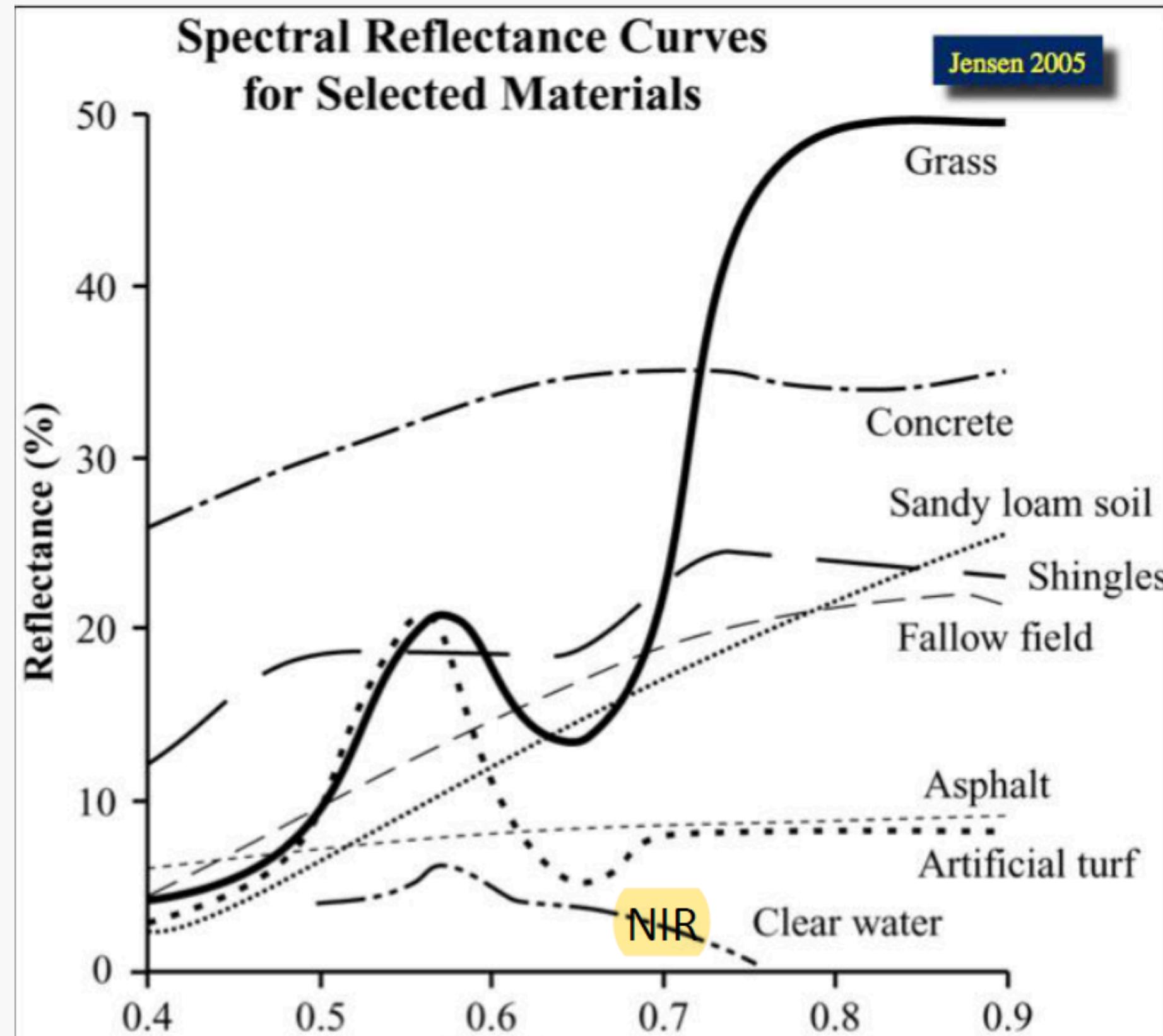
(Normalized Difference Vegetation Index)

- NIR (Nearest InfraRed) band is sensitive with plants.
- Plants absorb lots of Red radiation.
- By using Red Band and NIR band's reflectance, we can calculate a value to evaluate the condition of plants growth.

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$



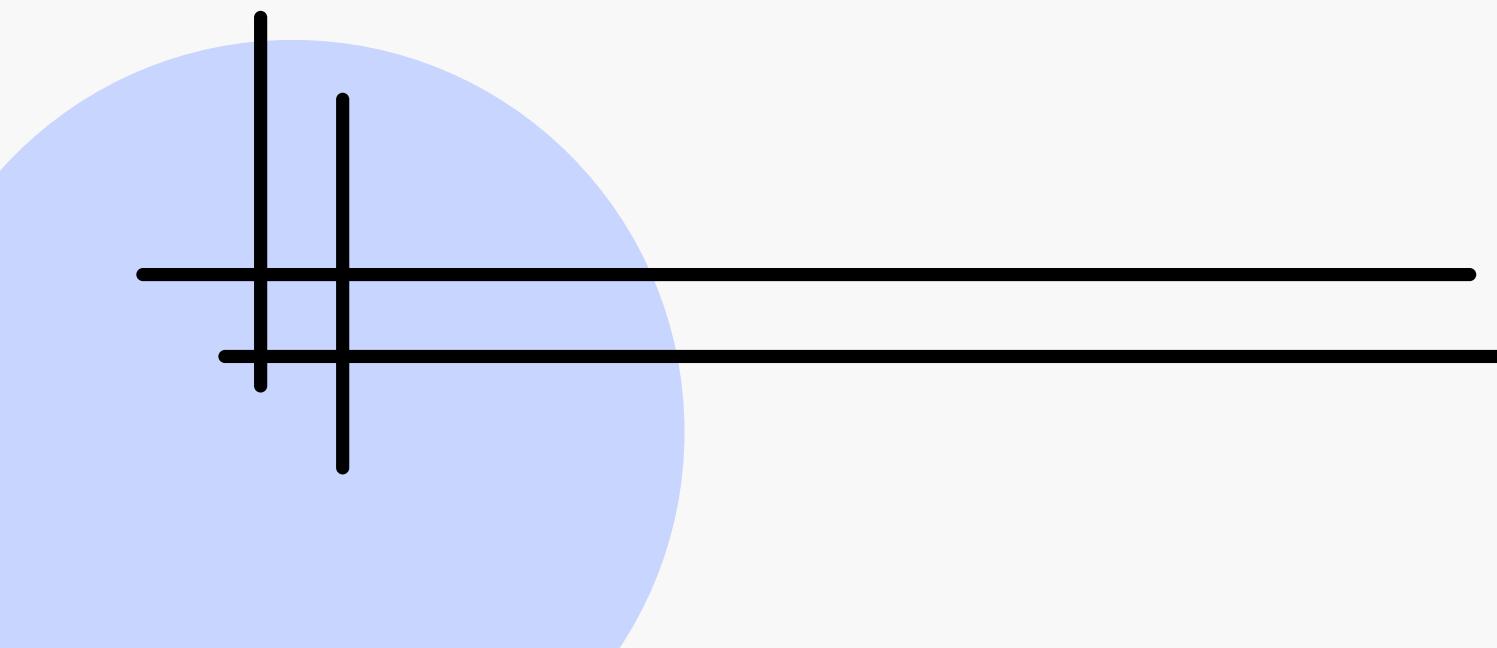
NDVI



Tools in ArcGIS Pro

Raster Calculator

- Raster Calculator can build and run a single map algebra expression using Python syntax.



Geoprocessing

Raster Calculator

Parameters Environments

Map Algebra expression

Rasters Tools

- RasterT_RasterC1_PointToRaster
- RasterC_1
- Reclass_tpe_1
- tpe_dtm.tif

Operators

- +
-
- *
- /

```
"tpe_dtm.tif" * "Reclass_tpe_1"
```

Output raster

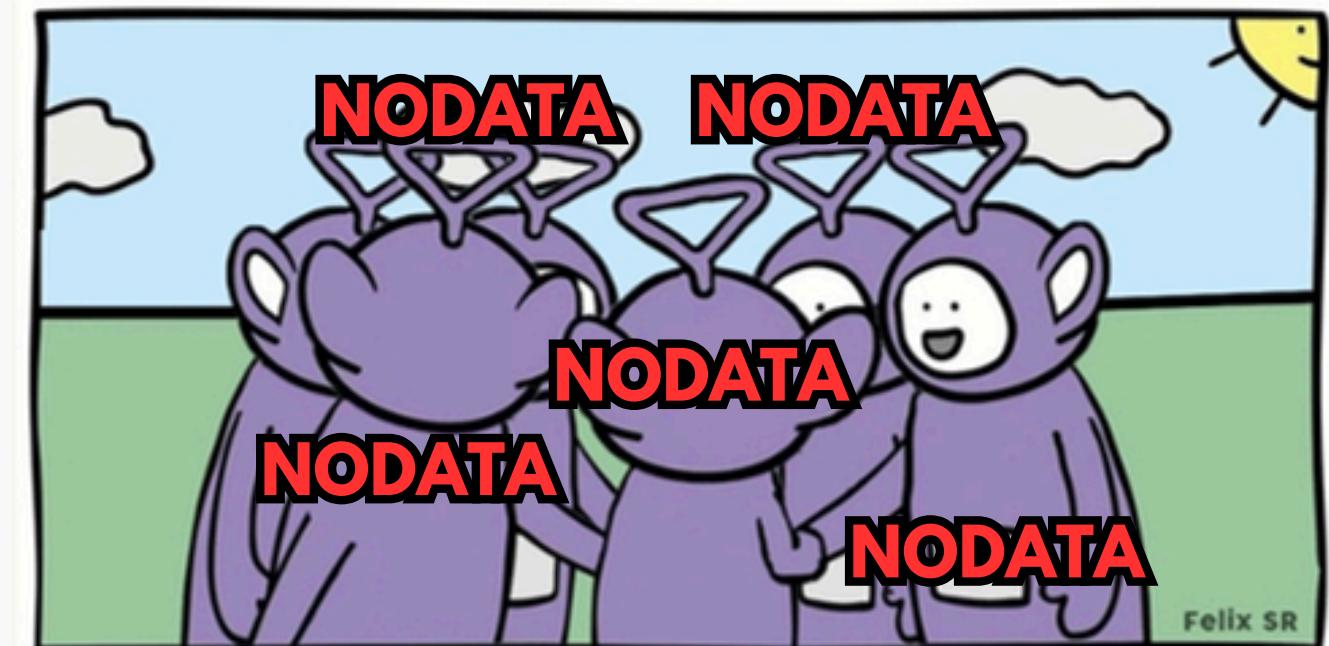
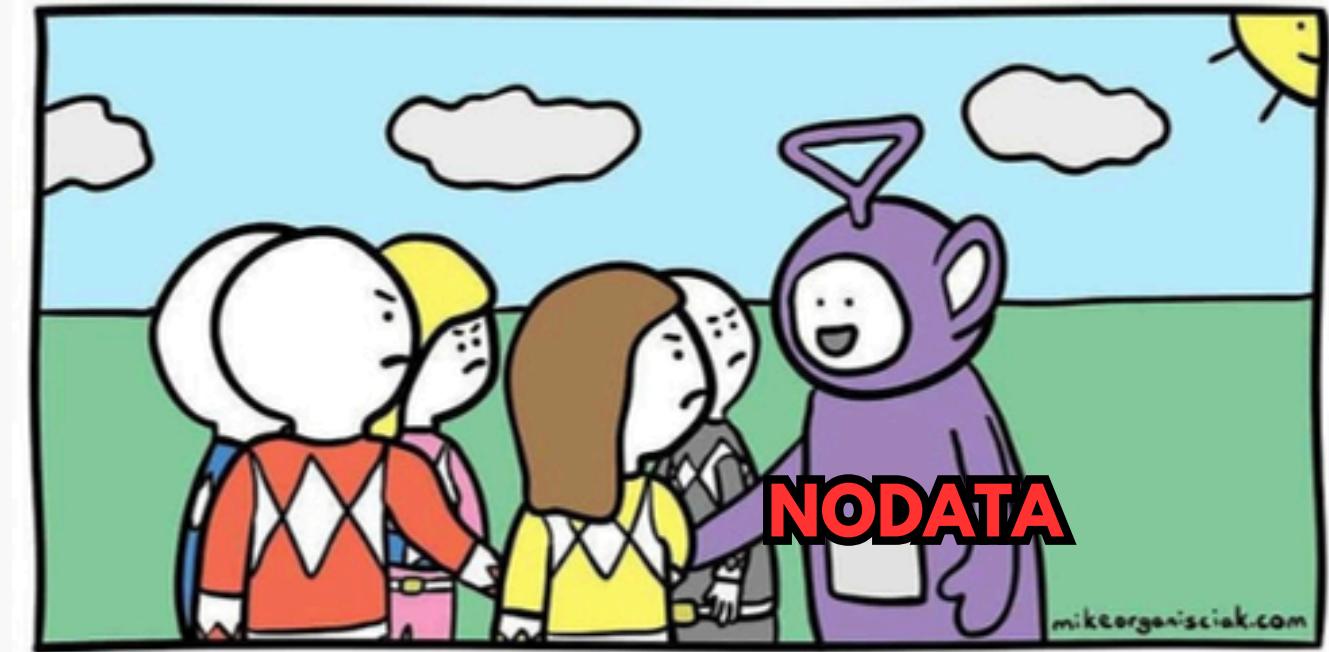
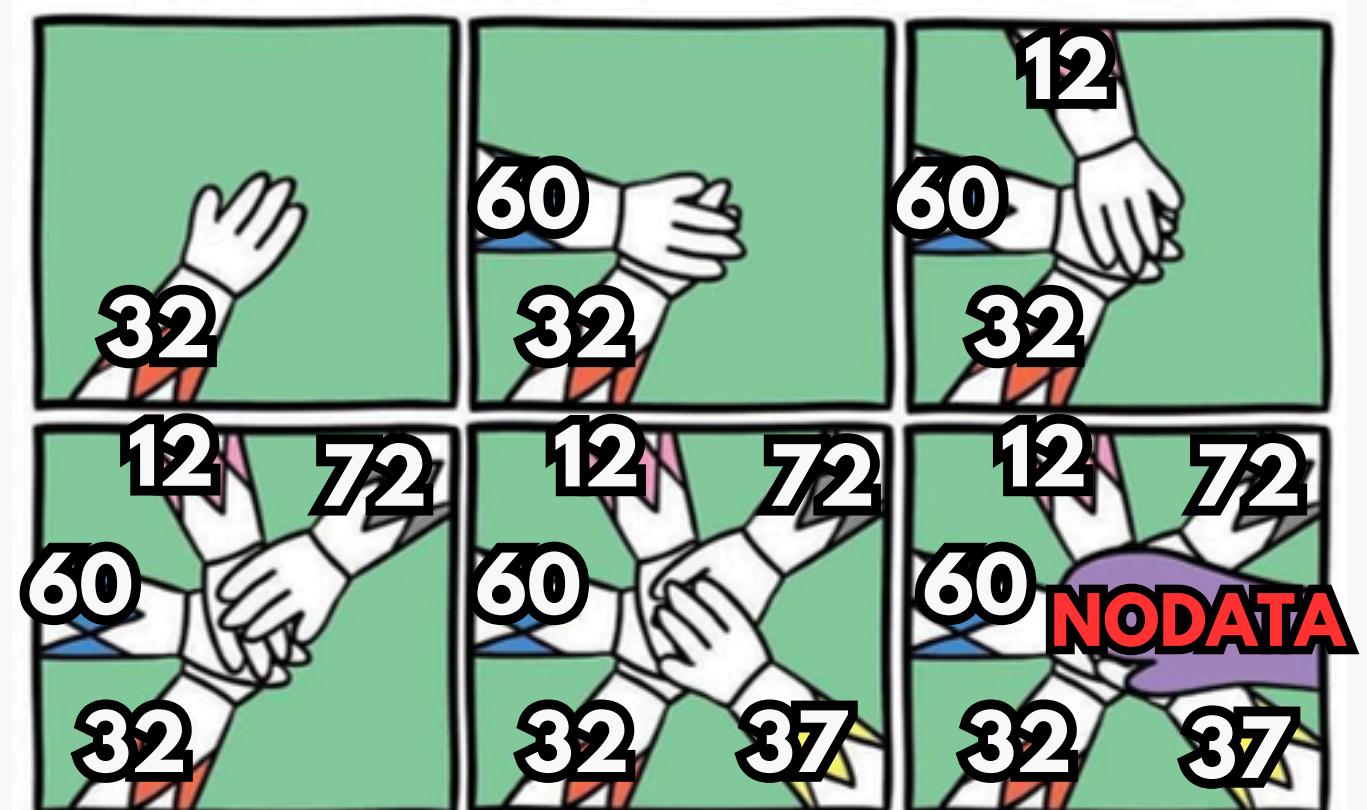
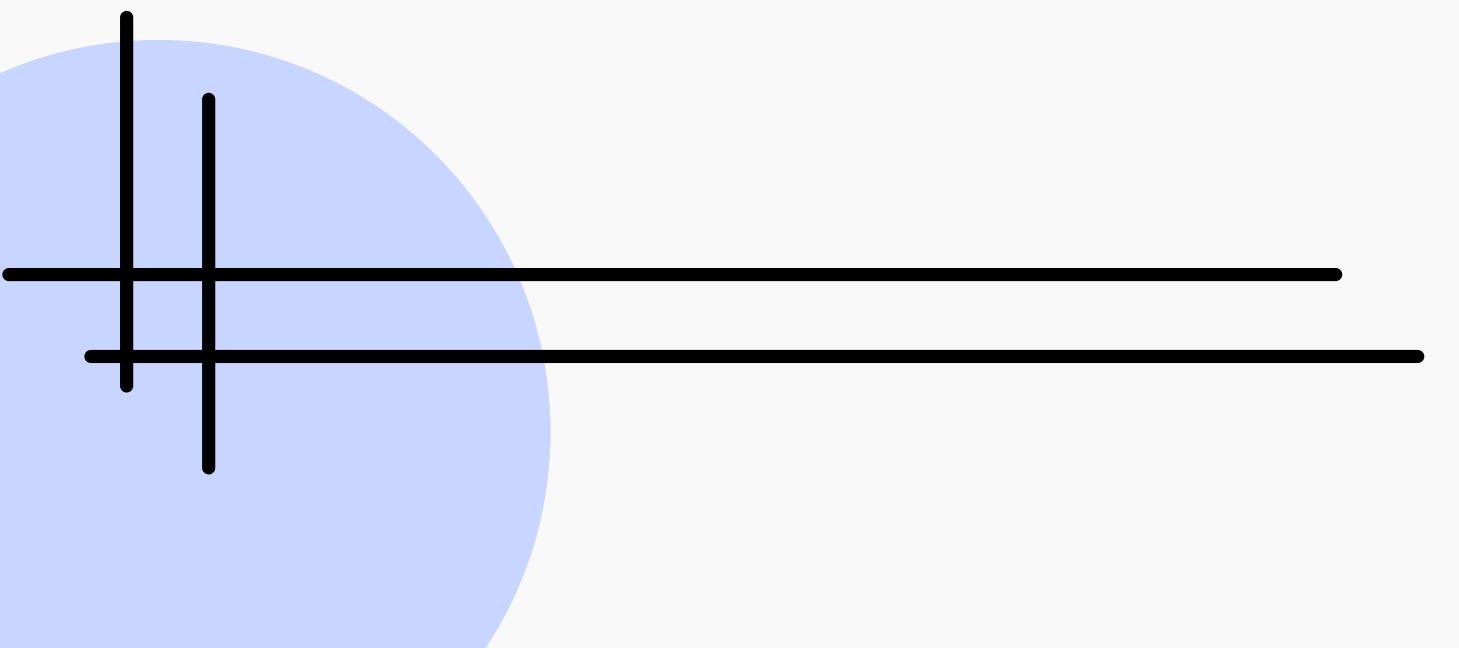
RasterC_1

Run

A screenshot of the ArcGIS Raster Calculator interface. The window title is "Geoprocessing" and the sub-tab is "Raster Calculator". The "Parameters" tab is selected. In the "Map Algebra expression" section, there is a list of rasters: "RasterT_RasterC1_PointToRaster", "RasterC_1", "Reclass_tpe_1", and "tpe_dtm.tif". To the right of the rasters is a "Tools" button. Below the rasters is a list of operators: "+", "-", "*", and "/". A red text box contains the expression: "'tpe_dtm.tif' * 'Reclass_tpe_1'". At the bottom left is an "Output raster" field containing "RasterC_1". At the bottom right is a "Run" button with a play icon.

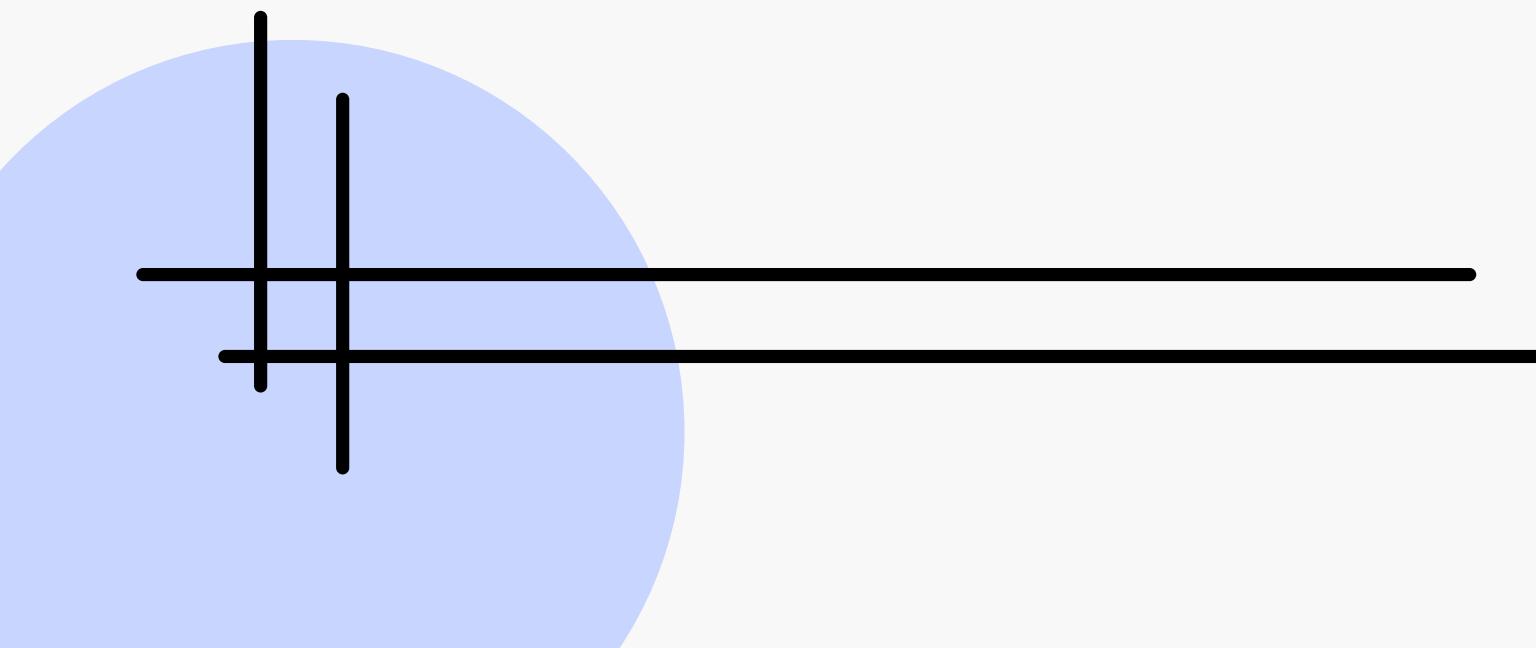
Raster Calculator

- Raster Calculator can build and run a single map algebra expression using Python syntax.



Reclassify

- Reclassifies (or changes) the values in a raster.



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Geoprocessing

Reclassify

Parameters Environments

Input raster
tpe_dtm.tif

Reclass field
Value

Reclassification

Reverse New Values

Start	End	New
-32768	-32768	NODATA
0	1114	1
NODATA	NODATA	NODATA

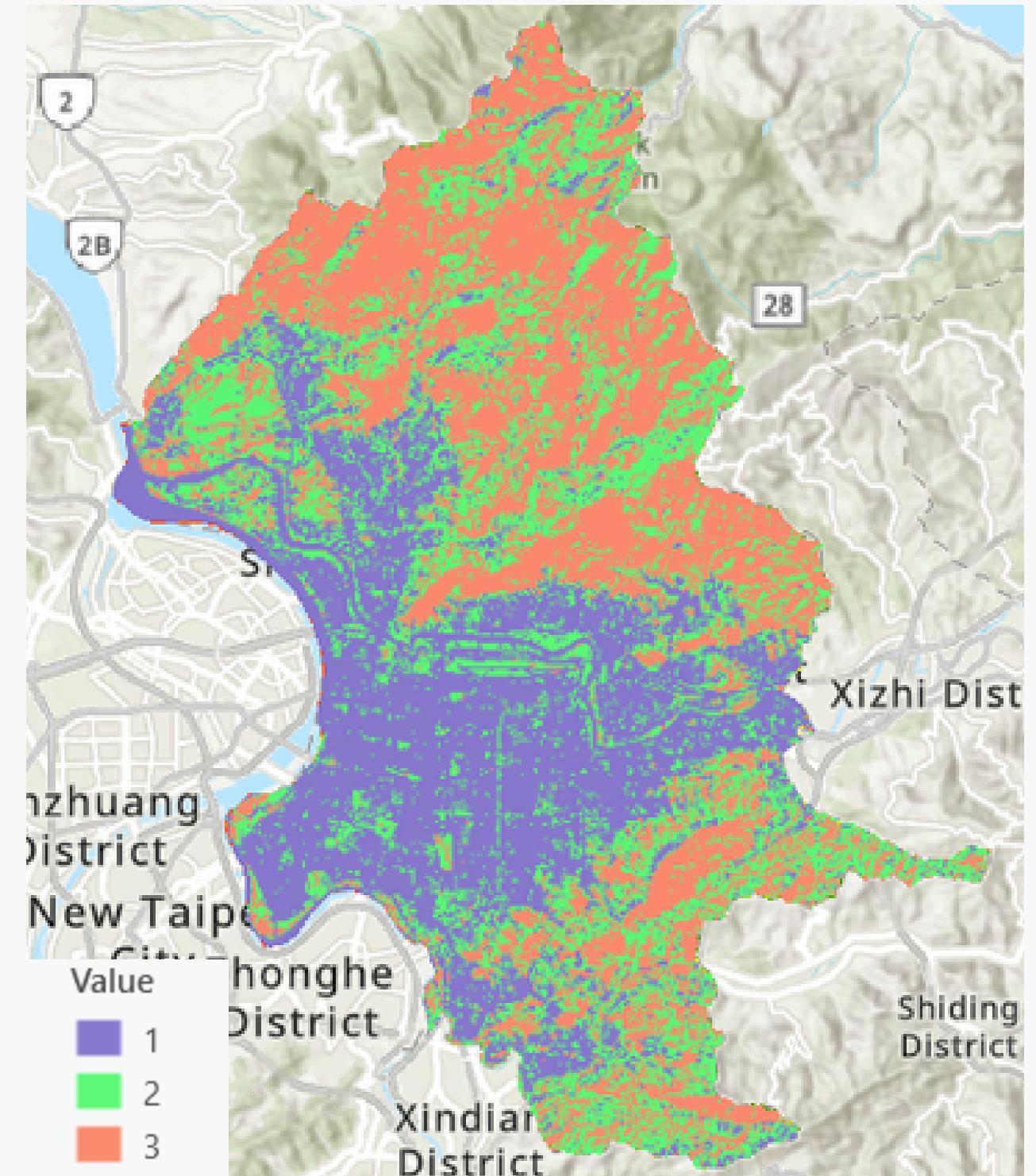
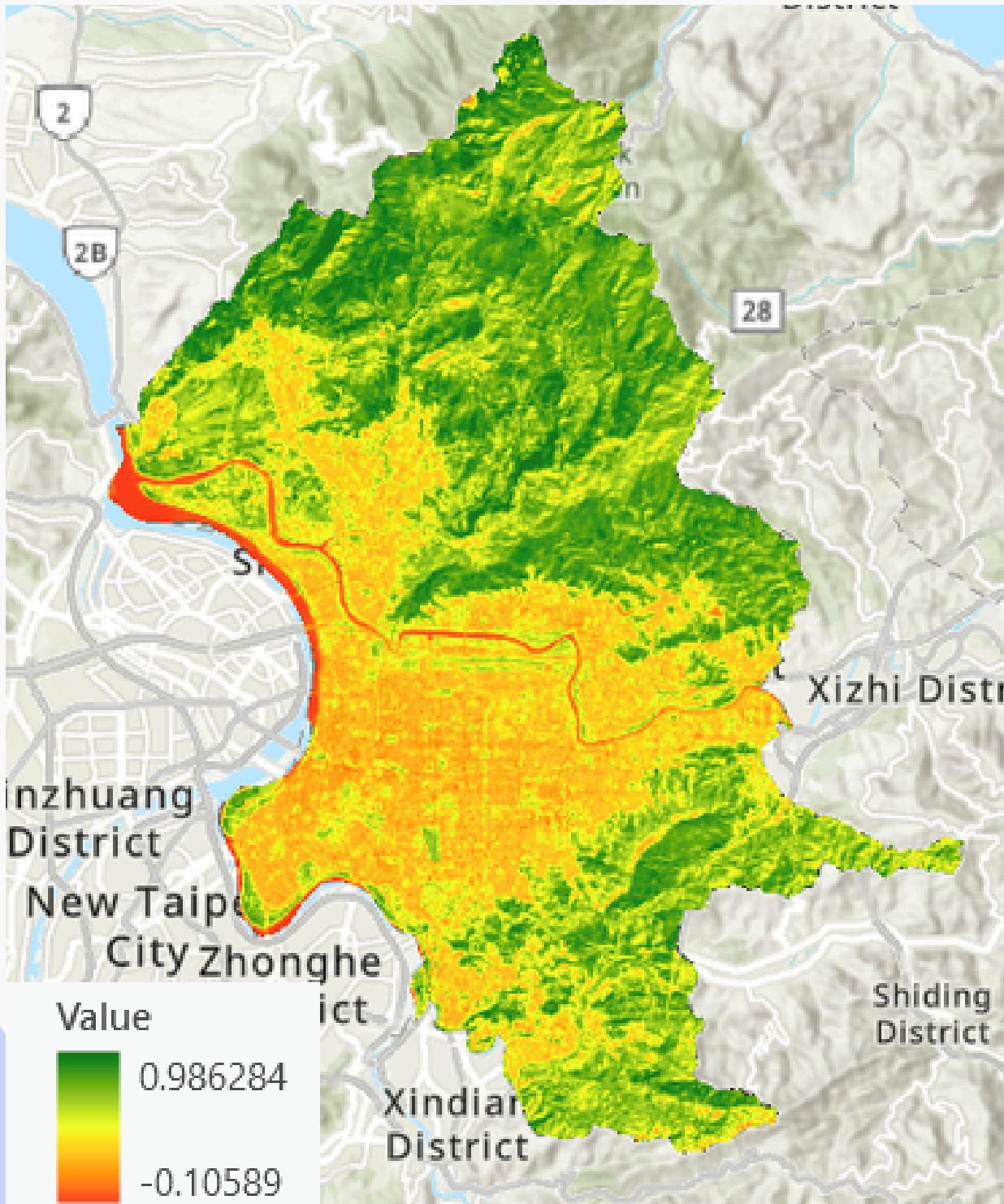
Classify Unique

Output raster
Reclass_tpe_1

Change missing values to NoData

Run

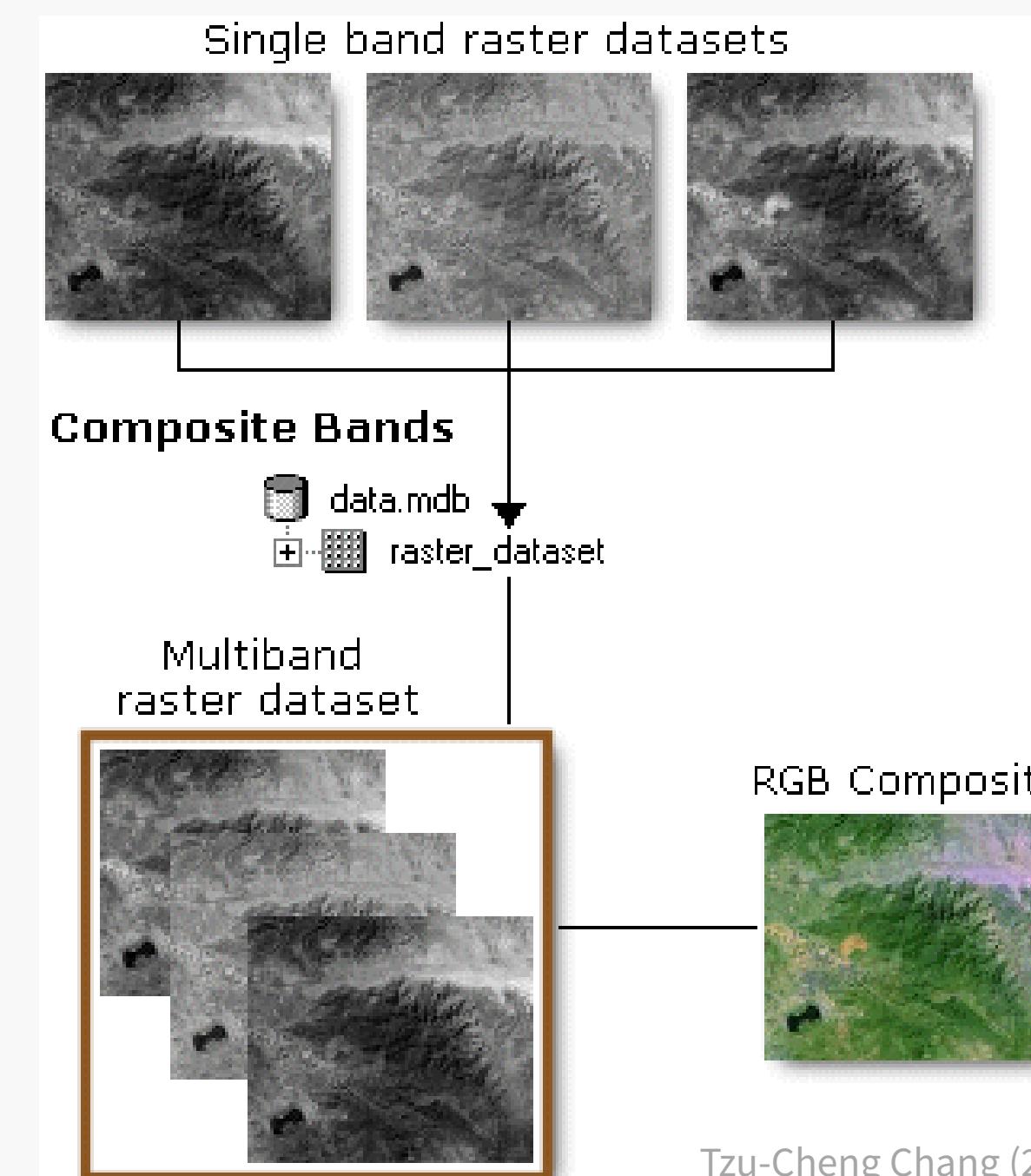
Reclassify



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Composite Bands

- Creates a single raster dataset from multiple bands.



Geoprocessing

Composite Bands

Parameters Environments

Input Rasters

- LC08_L2SP_117043_20231208_20231214_02_T1_SR_B2.TIF
- LC08_L2SP_117043_20231208_20231214_02_T1_SR_B3.TIF
- LC08_L2SP_117043_20231208_20231214_02_T1_SR_B4.TIF
- LC08_L2SP_117043_20231208_20231214_02_T1_SR_B5.TIF

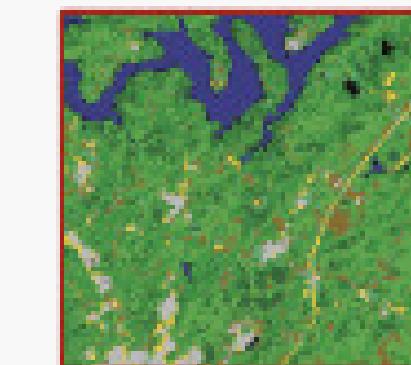
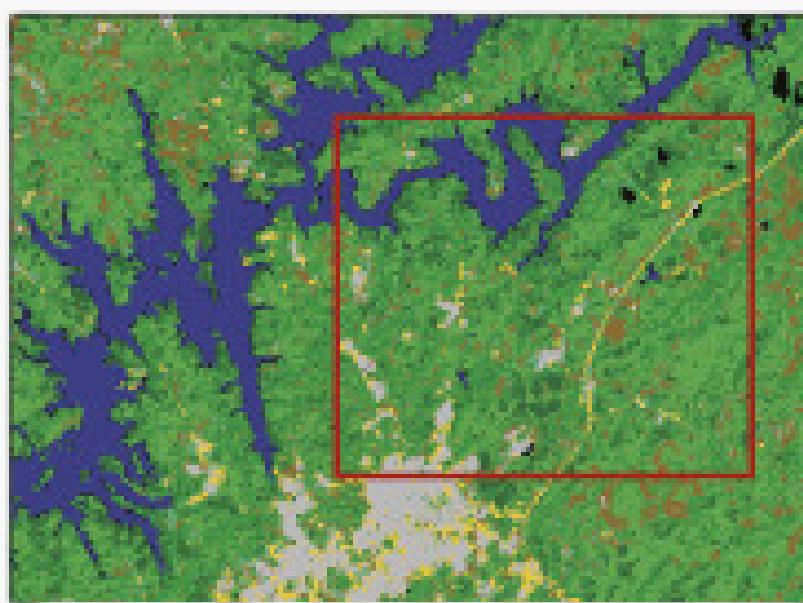
Output Raster

LC08_L2SP_117043_20231208_20231214_02_T1_SR

Run

Clip Raster

- Cuts out a portion of a raster dataset, mosaic dataset, or image service layer.



Geoprocessing



Clip Raster



Parameters Environments

Input Raster

ter_try.gdb\LC08_L2SP_117043_20231208_20231214_02_T1_SR



Output Extent

TPE_Village



Rectangle



X and Y Extent

Top

2788997.07046739

Left

344435.614106789

Right

365405.35529387

Bottom

2761305.60115984

Output Raster Dataset

LC08_L2SP_117043_202312_Clip



Use Input Features for Clipping Geometry

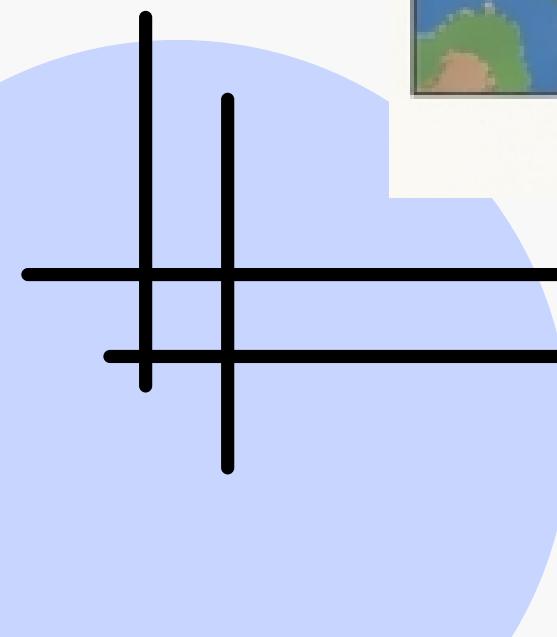
NoData Value

-1

Maintain Clipping Extent

Extract by Mask

- Extracts the cells of a raster that correspond to the areas defined by a mask.



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Geoprocessing Run

Extract by Mask

Parameters Environments

Input raster
LC08_L2SP_117043_20231208_20231214_02_T1_SR

Input raster or feature mask data
TPE_Village

Output raster
Extract_LC081

Extraction Area
Inside

Analysis Extent

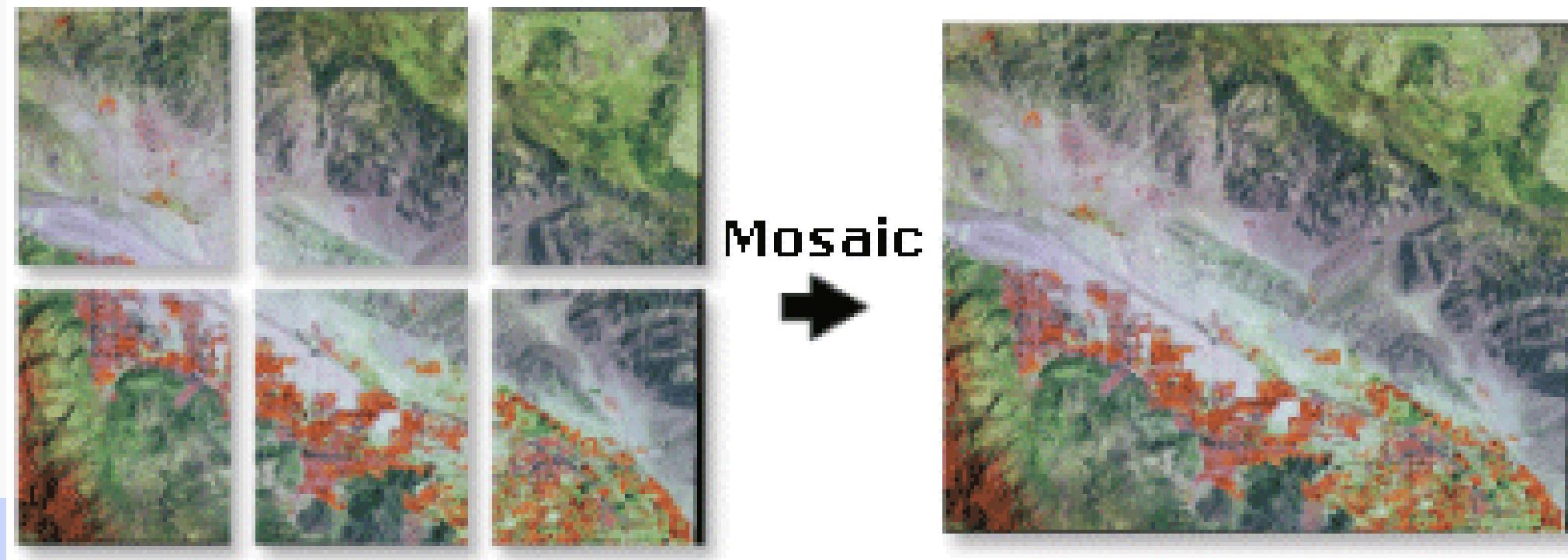
X and Y Extent

Top	2789150.23229249
Left	344195.025331714
Right	365700.555814785
Bottom	2761203.98190393

Extent Coordinate System
WGS 1984 UTM Zone 51N

Mosaic to New Raster

- Merges multiple raster datasets into a new raster dataset.



Geoprocessing

Mosaic To New Raster

Parameters Environments

* Input Rasters

* Output Location

* Raster Dataset Name with Extension

Spatial Reference for Raster

Pixel Type

Cellsize

* Number of Bands

Mosaic Operator

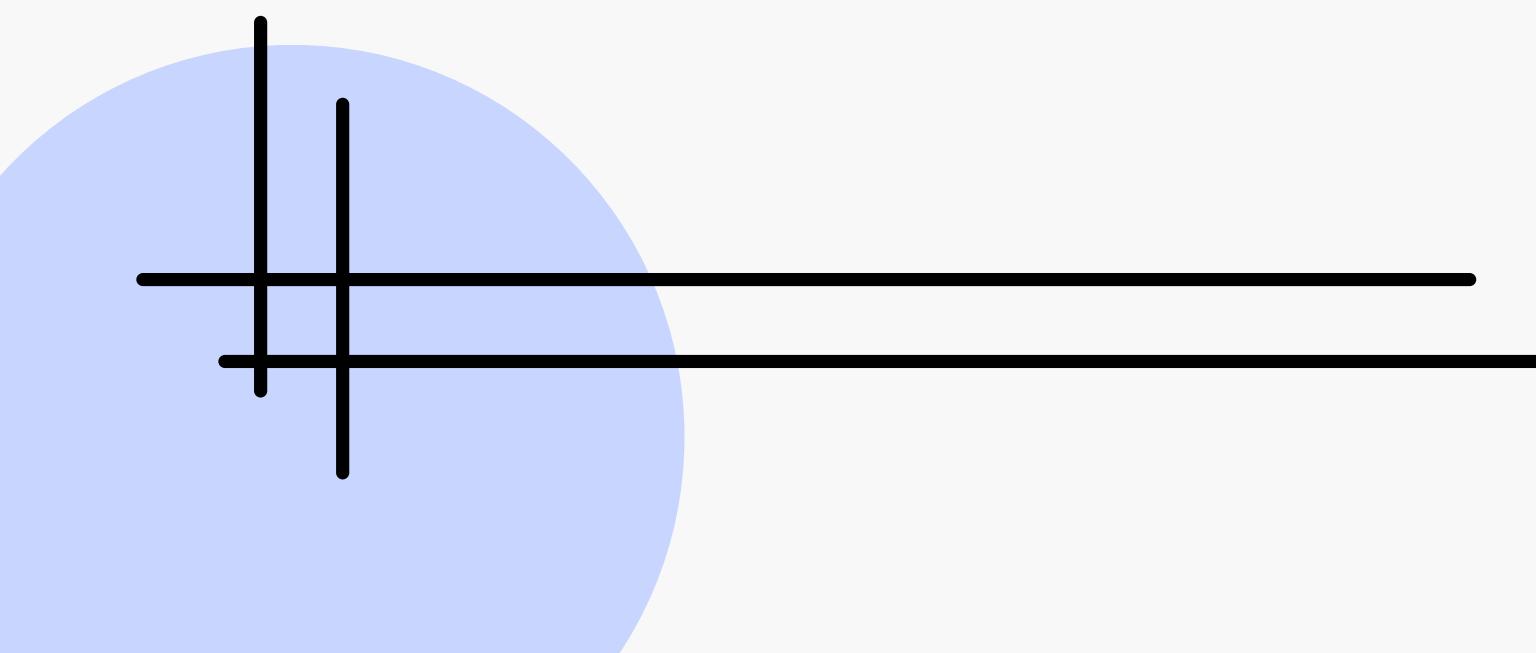
Mosaic Colormap Mode

Run

This screenshot shows the 'Mosaic To New Raster' geoprocessing tool interface. It includes fields for input rasters, output location, raster dataset name, spatial reference, pixel type, cell size, number of bands, mosaic operator, and colormap mode. A 'Run' button is at the bottom right.

Mosaic to New Raster

- Merges multiple raster datasets into a new raster dataset.
- Pixel type => Depth e.g. 8bit
 - Unsigned: 0 ~ 255
 - Signed: -128 ~ 127



Geoprocessing

Mosaic To New Raster

Parameters Environments

* Input Rasters

* Output Location

* Raster Dataset Name with Extension

Spatial Reference for Raster

Pixel Type

Cellsize

* Number of Bands

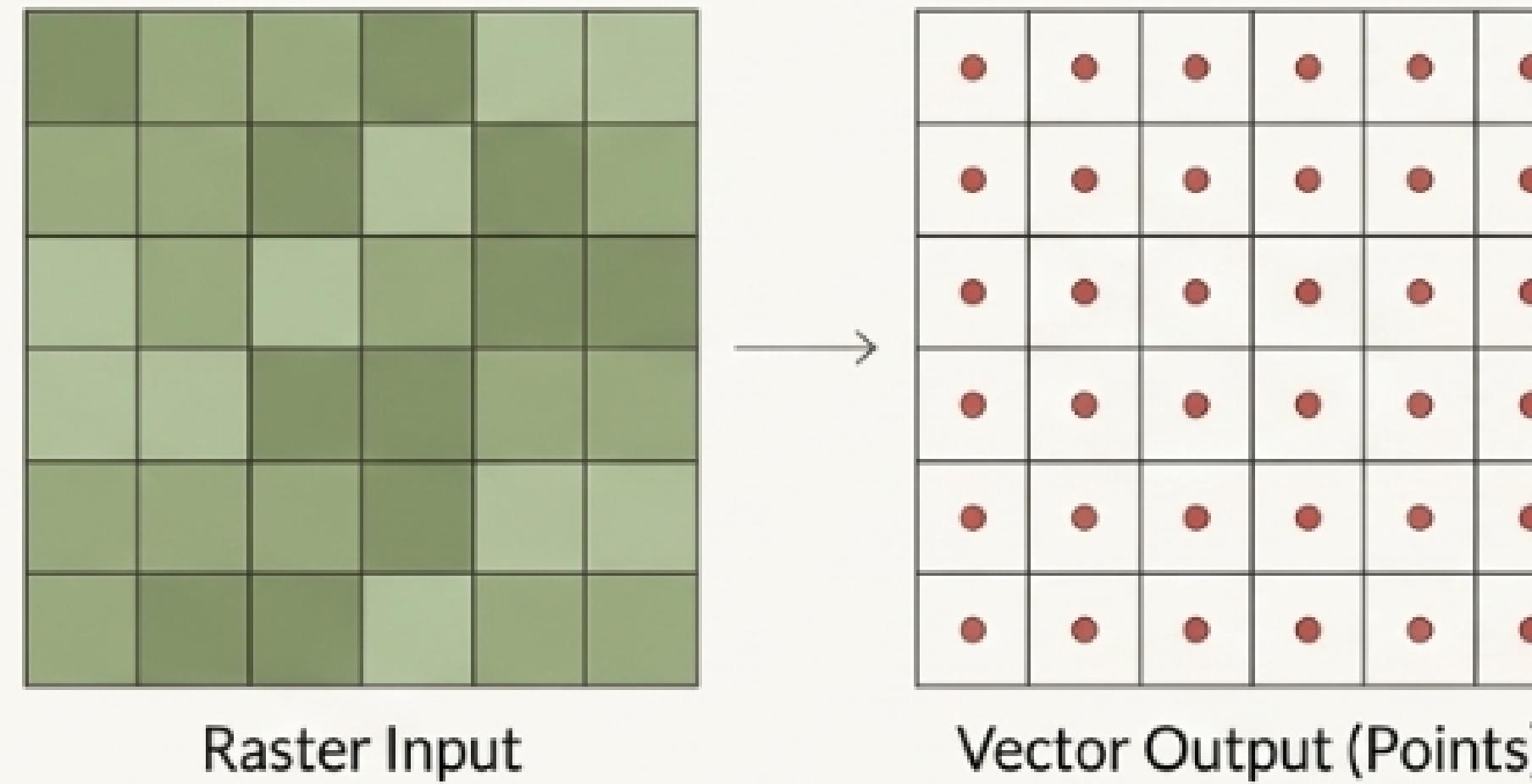
Mosaic Operator

Mosaic Colormap Mode

Run

Point Raster Conversion

- Converts a raster dataset to point features.



Geoprocessing



Raster to Point



Parameters Environments

* Input raster



Field

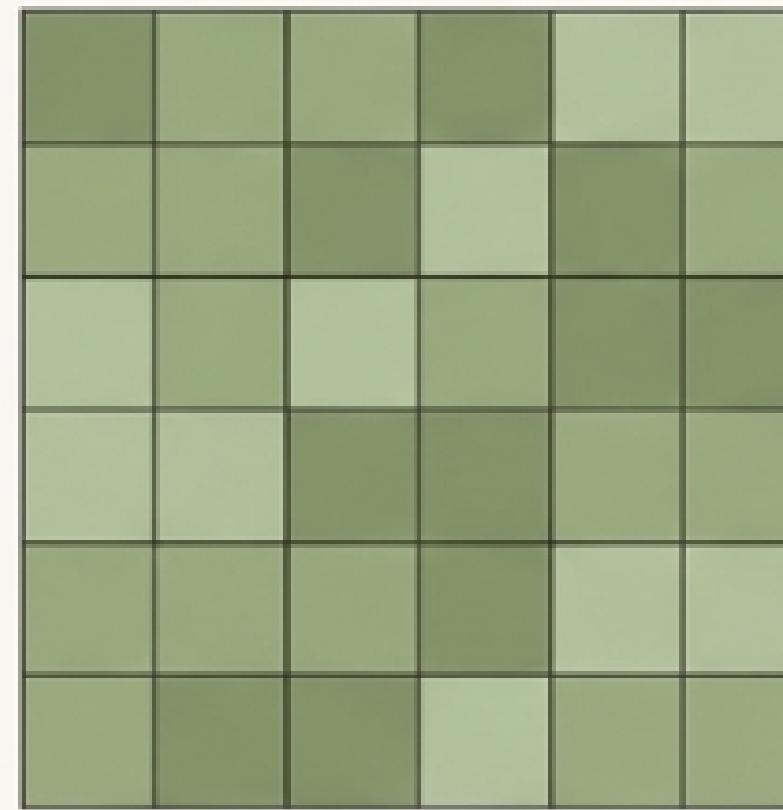


* Output point features

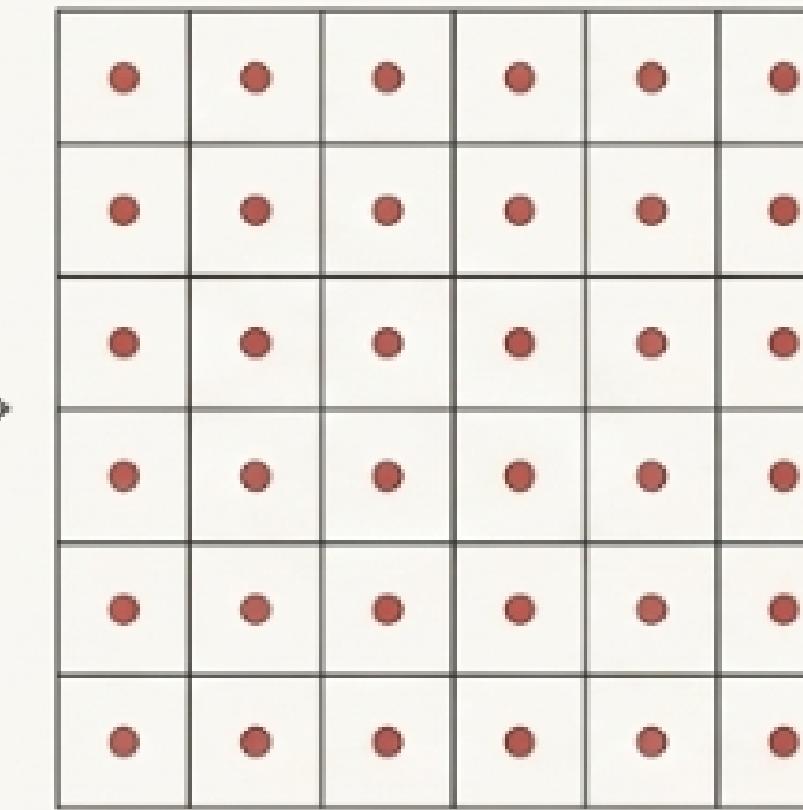


Point Raster Conversion

- Converts a point features to raster dataset.



Raster Input



Vector Output (Points)

Geoprocessing

Point to Raster

Parameters Environments

* Input Features

* Value field

* Output Raster Dataset

Cell assignment type
Most frequent

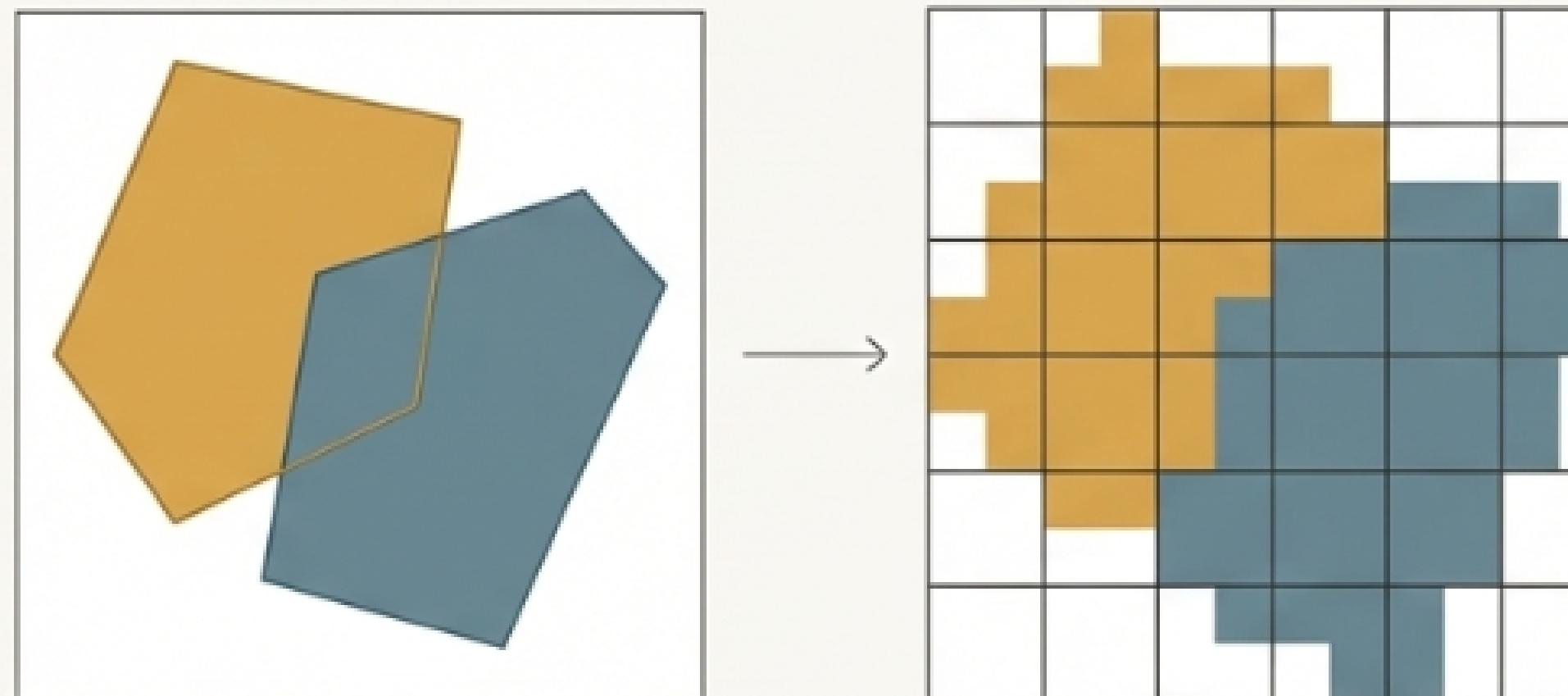
Priority field
NONE

Cellsize

Build raster attribute table

Polygon Raster Conversion

- Converts a raster dataset to features.



Vector Input

Raster Output

Geoprocessing

Raster to Polygon

Parameters Environments

Input raster: RasterT_RasterC3_PointToRaster

Field: Value

Output polygon features: RasterT_RasterT1

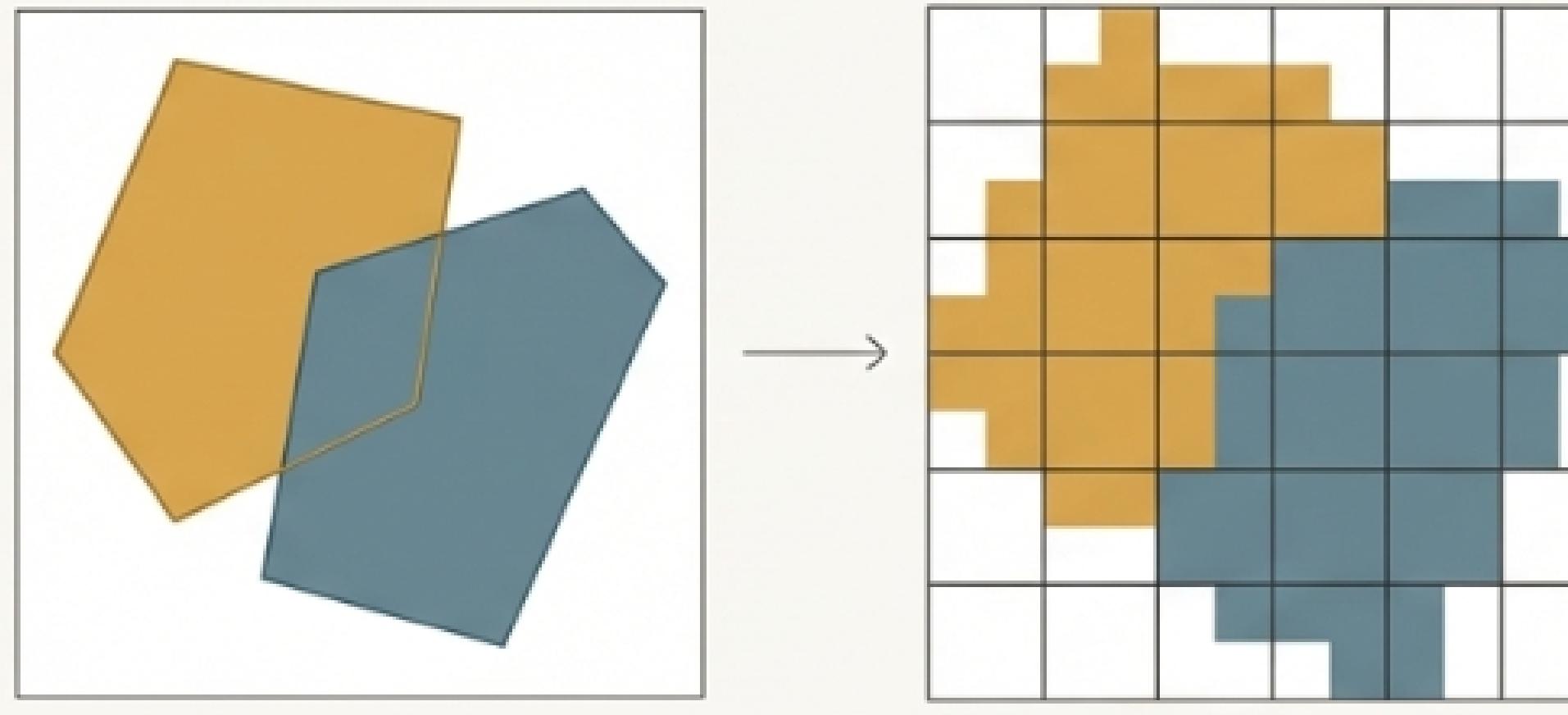
Simplify polygons

Create multipart features

Maximum vertices per polygon feature: [empty field]

Polygon Raster Conversion

- Converts a features to raster dataset.



Vector Input

Raster Output

Geoprocessing

Polygon to Raster

Parameters Environments

* Input Features

* Value field

* Output Raster Dataset

Cell assignment type Cell center

Priority field NONE

Cellszie

Build raster attribute table

Raster Domain

- Converts a raster dataset to features.

Geoprocessing

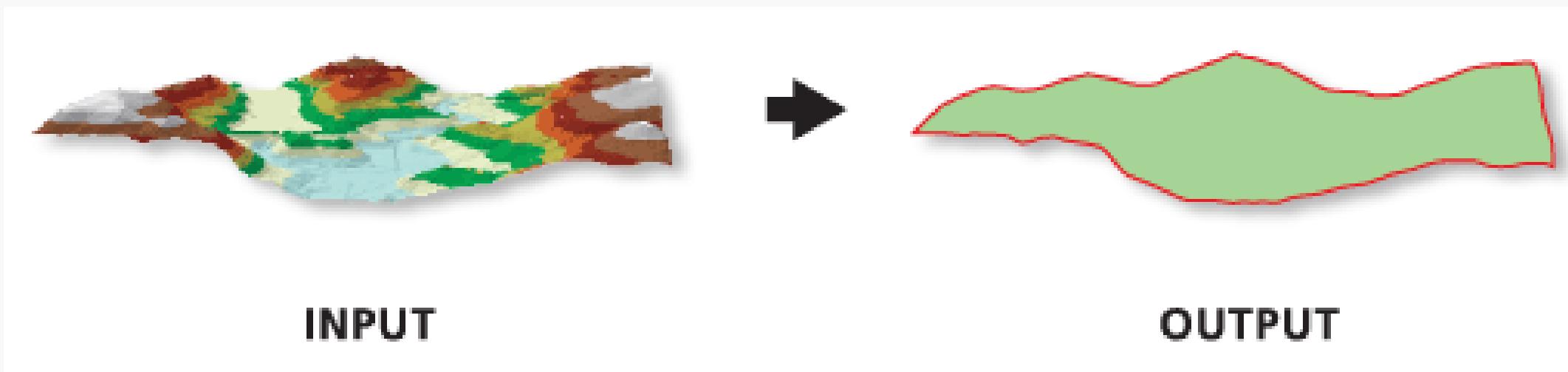
Raster Domain

Parameters Environments

i Input Raster
RasterT_RasterC2_PointToRaster

! Output Feature Class
RasterT_RasterC_RasterDomain

Output Feature Class Type
Polygon



Raster Operation



Flooding Potential Area

■ Lab Practice I - Calculate total non-affected population with 20m height flooding area.

Using Population csv to calculate each village's population density.

After erasing the flooding area, using remaining area and population density to estimate non-affected population.

Flooding Potential Area - 20m

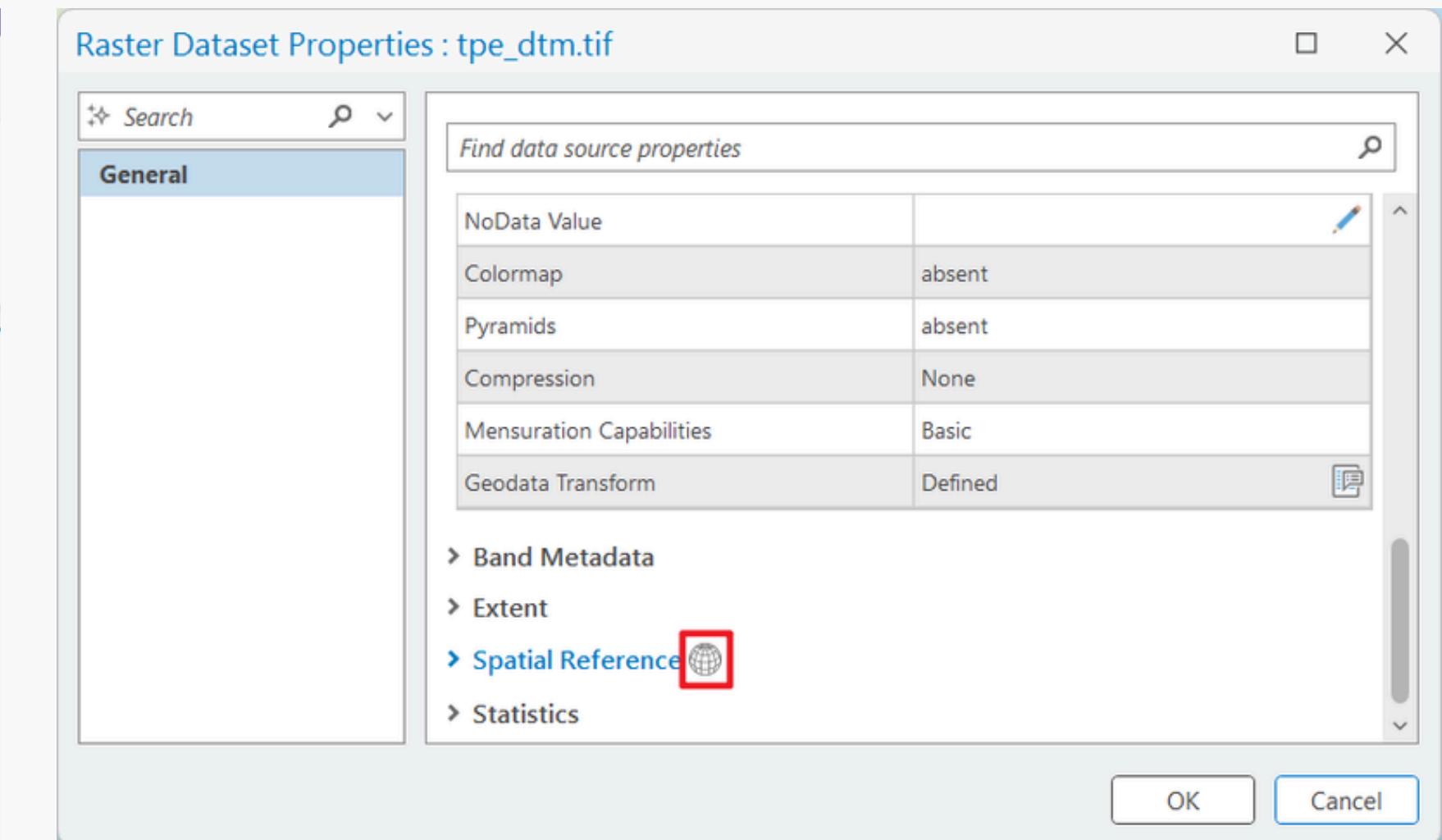
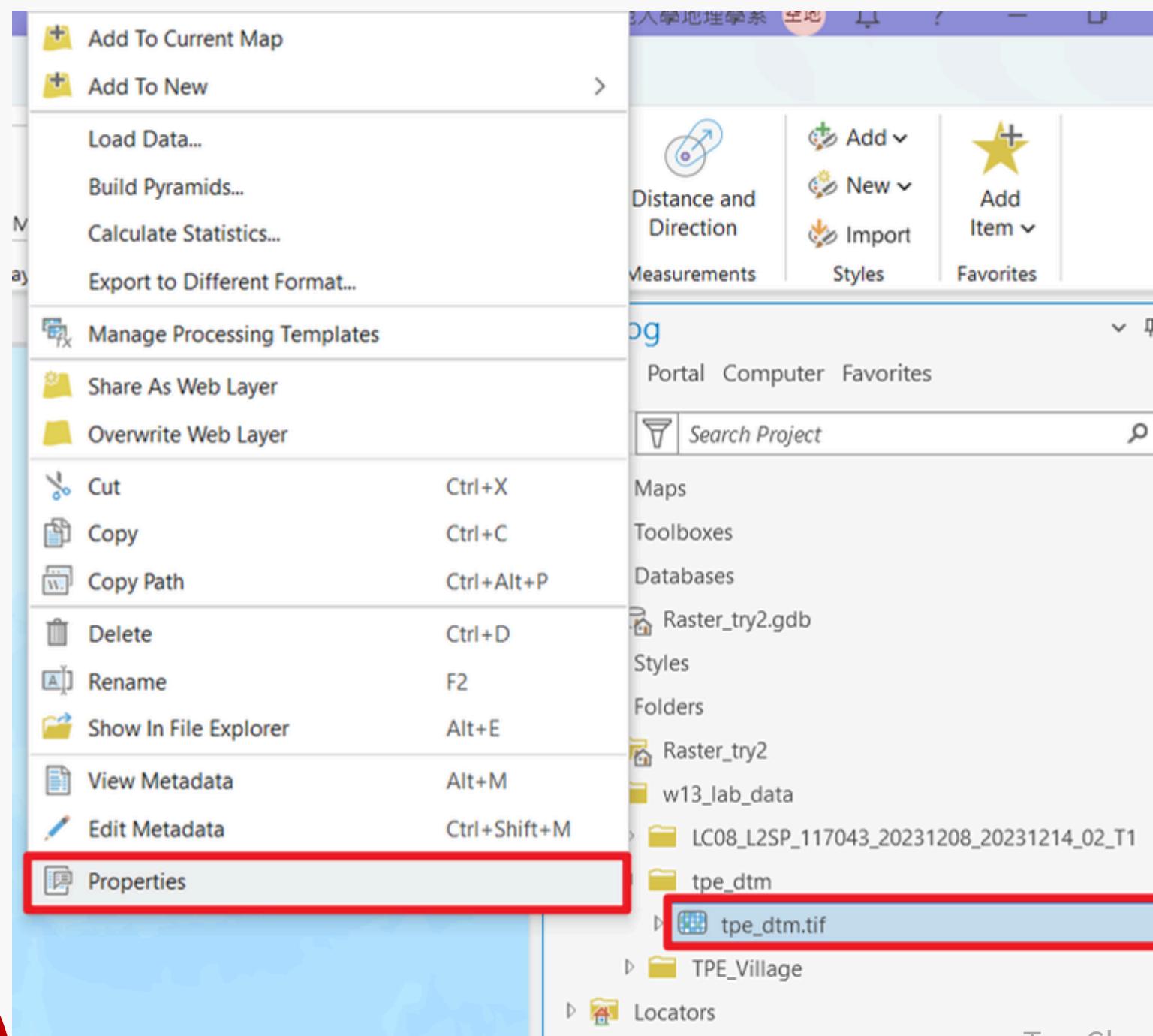
- Setting Coordinate System
- Raster Preprocessing
 - Reclassify
 - Raster Claculator
- Raster to Point
- Select by Attribute
- Point to Raster
- Raster to Feature

兄弟
座標系統設了嗎



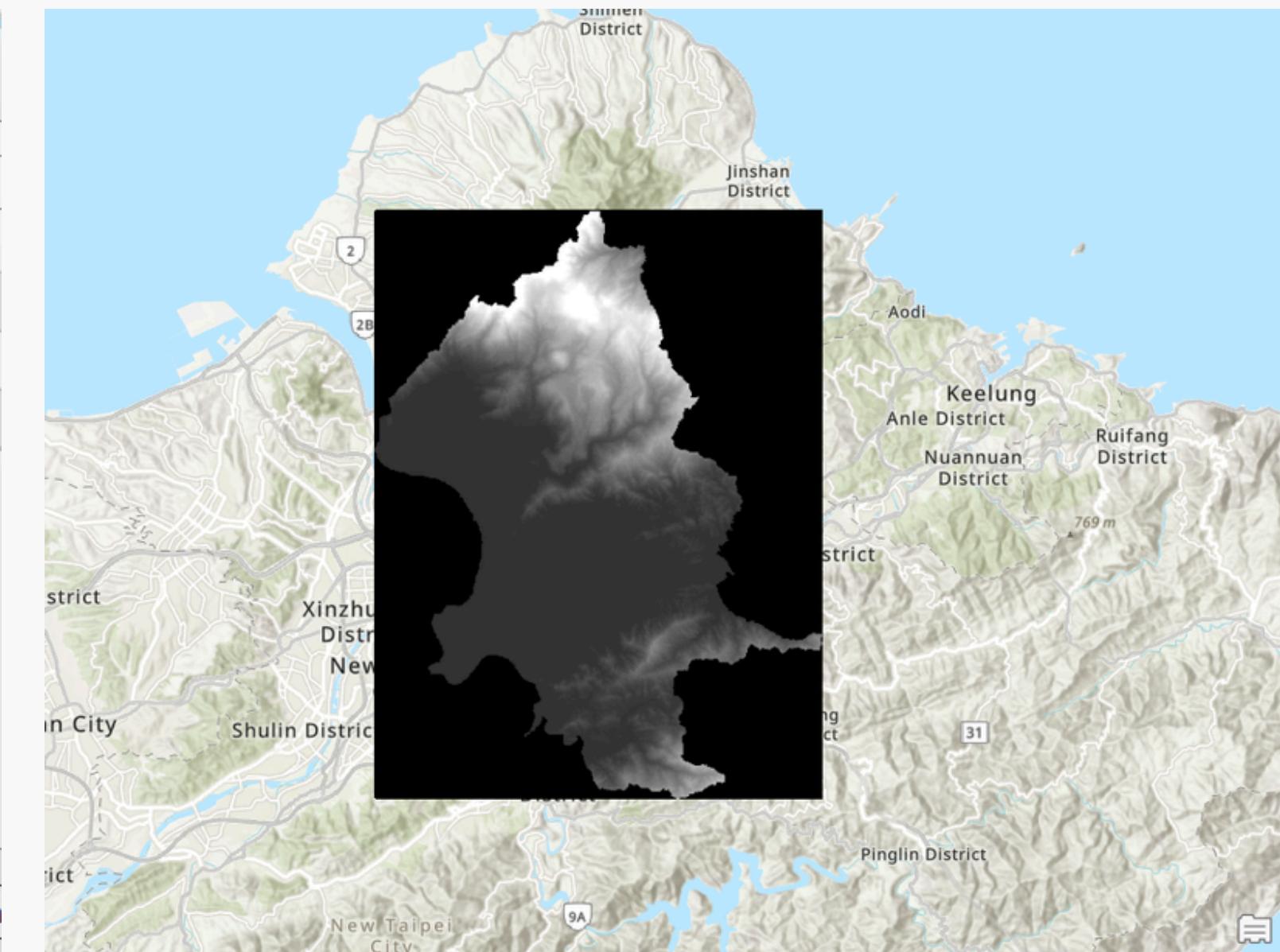
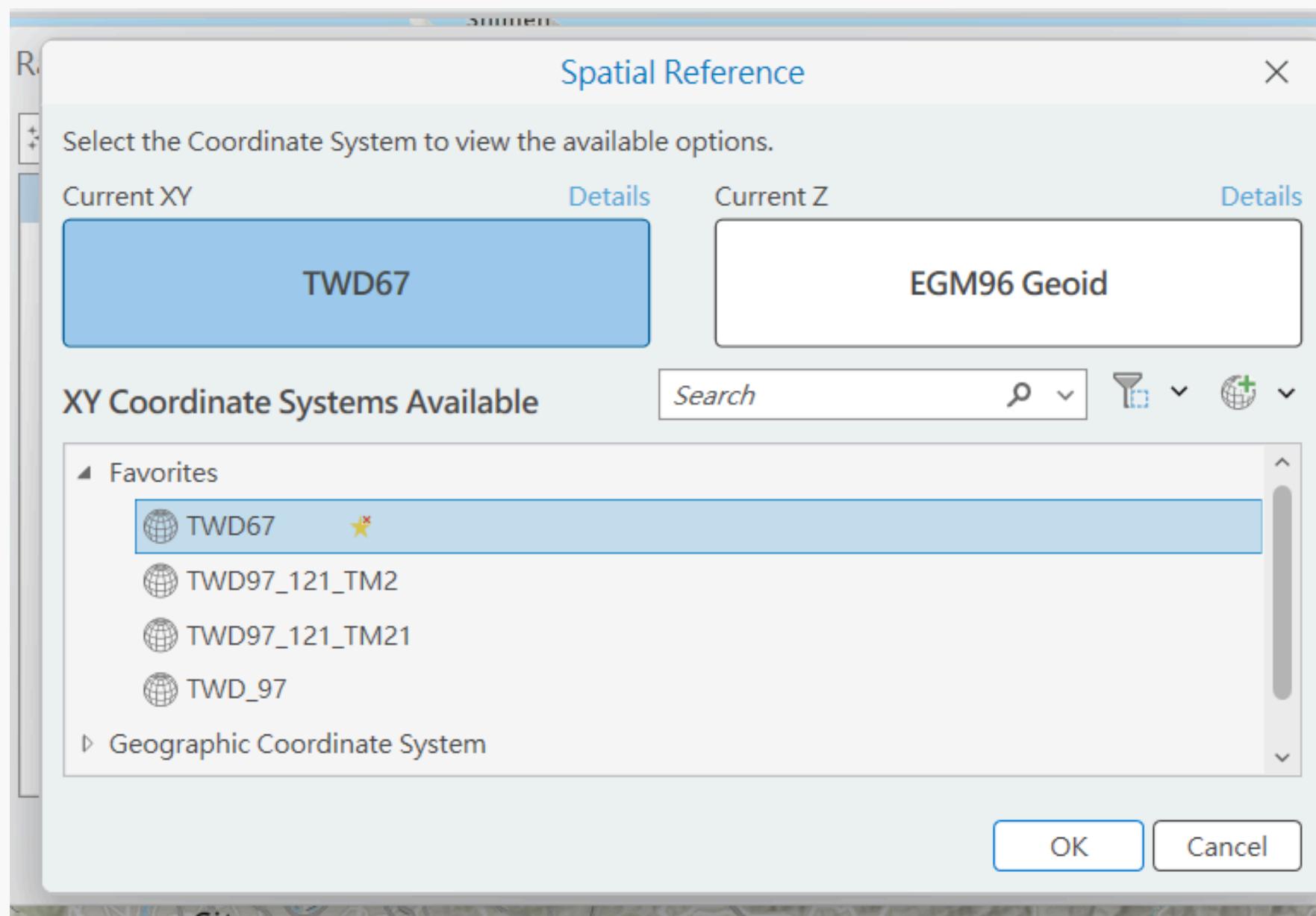
Flooding Potential Area

Setting Coordinate System



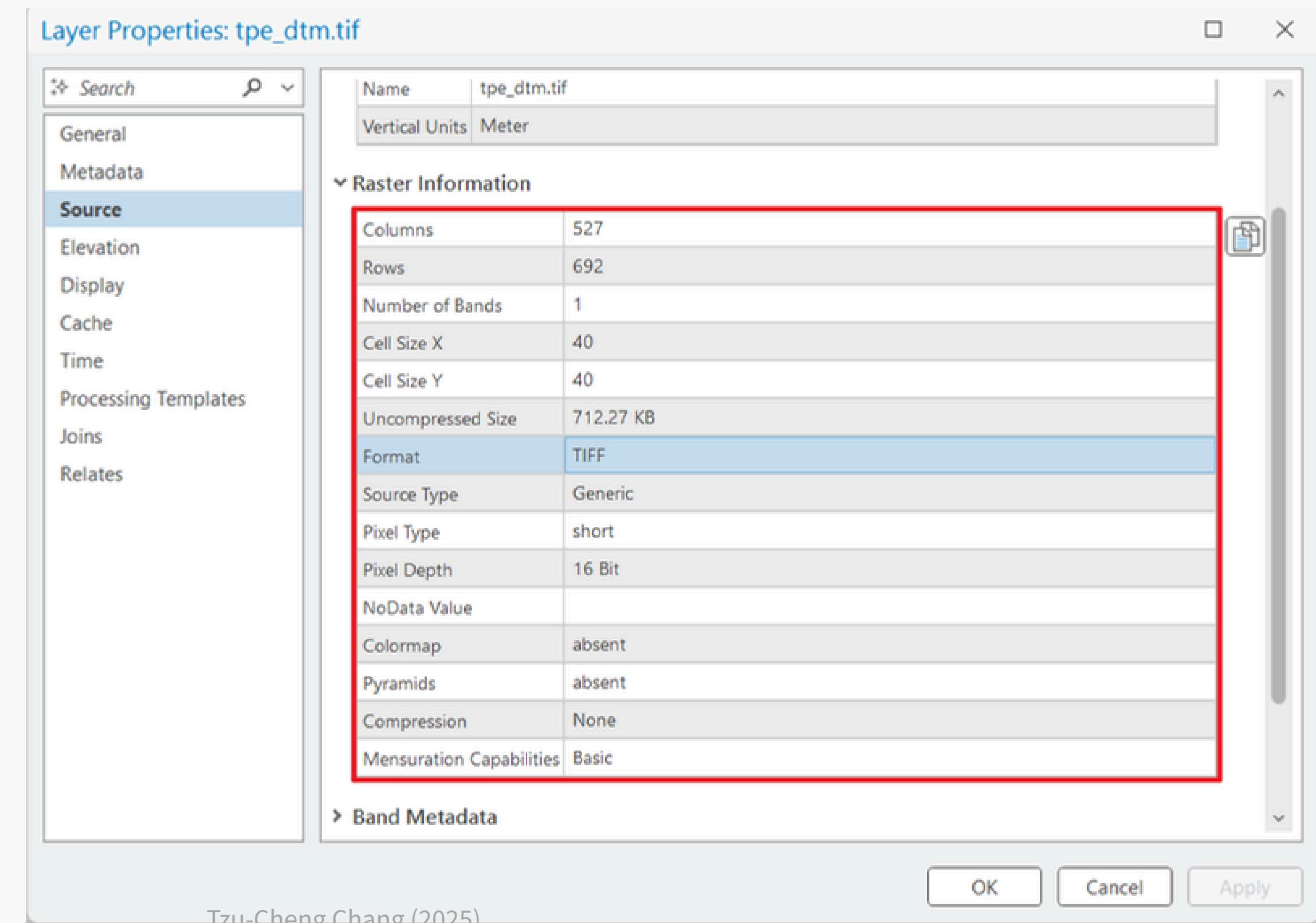
Flooding Potential Area

■ Setting Coordinate System



Flooding Potential Area

Raster Property



Flooding Potential Area

■ Preprocessing - Reclassify

The screenshot shows the ArcGIS Pro interface for a geoprocessing task. On the left, the 'Geoprocessing' pane displays the 'Reclassify' tool. The 'Parameters' tab is selected. Key fields highlighted with red boxes are: 'Reclass field' (dropdown menu), 'Value' (dropdown menu), and the 'Classify' button in the 'Reclassification' section. Other visible parameters include 'Input raster' (tpe_dtm.tif), 'Output raster' (Reclass_tpe_1), and a checkbox for 'Change missing values to NoData'. On the right, a 'Classify' dialog box is open, showing the 'Natural Breaks (Jenks)' method with 2 classes. The histogram table is as follows:

Upper value	Count
≤ -32768.0	1
≤ 1114.0	2

At the bottom right of the dialog are 'OK' and 'Cancel' buttons.

Flooding Potential Area

■ Preprocessing - Reclassify

Geoprocessing

Reclassify

Parameters Environments

Input raster
tpe_dtm.tif

Reclass field
Value

Reclassification

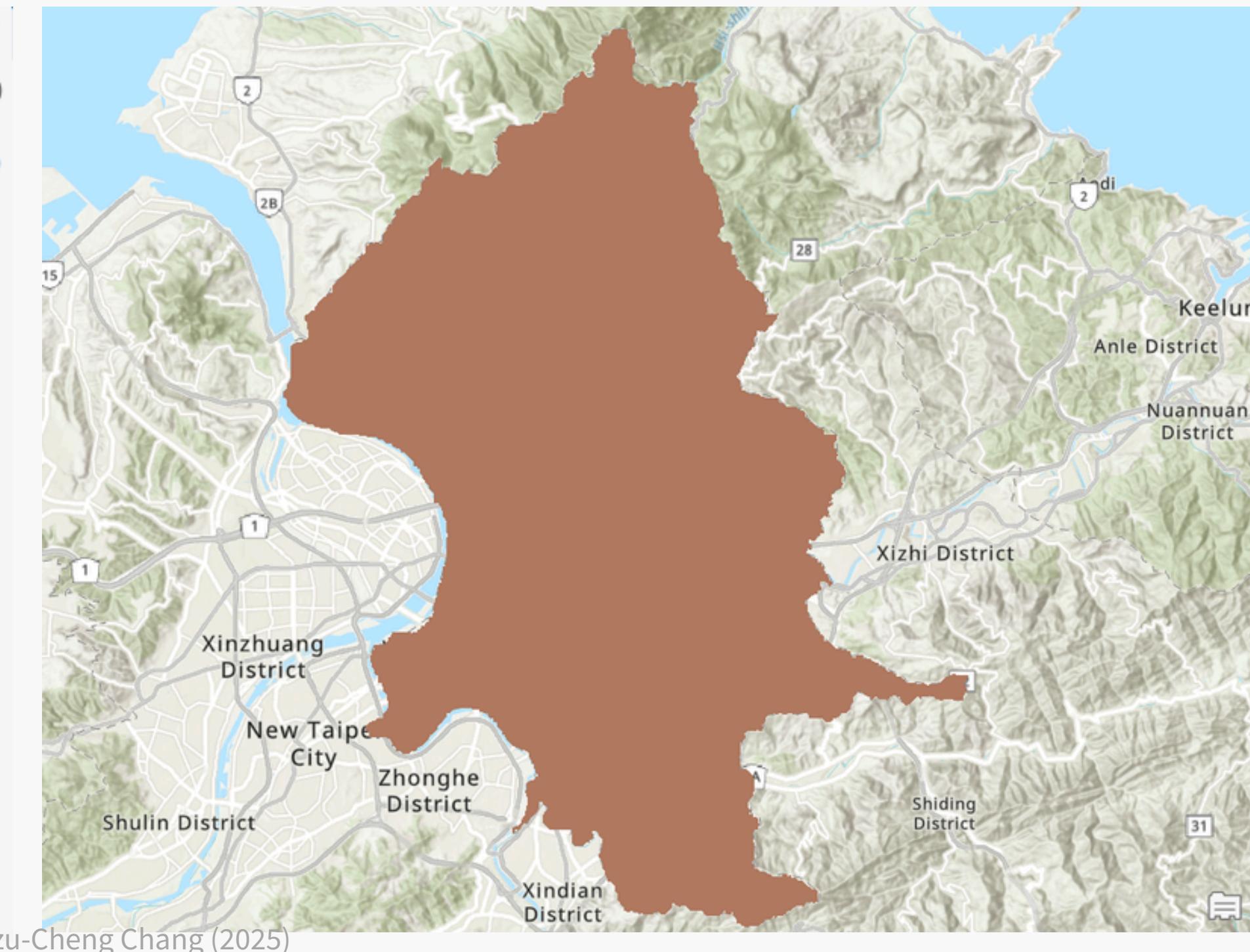
Reverse New Values

Start	End	New
-32768	-32768	NODATA
0	1114	1
NODATA	NODATA	NODATA

Classify Unique

Output raster
Reclass_tpe_1

Change missing values to NoData



Flooding Potential Area

■ Preprocessing - Raster Calculator

Geoprocessing

Raster Calculator

Parameters Environments

Map Algebra expression

Rasters

- Reclass_tpe_1
- tpe_dtm.tif
- 不分幅_台灣20MDEM(2024).tif

Tools

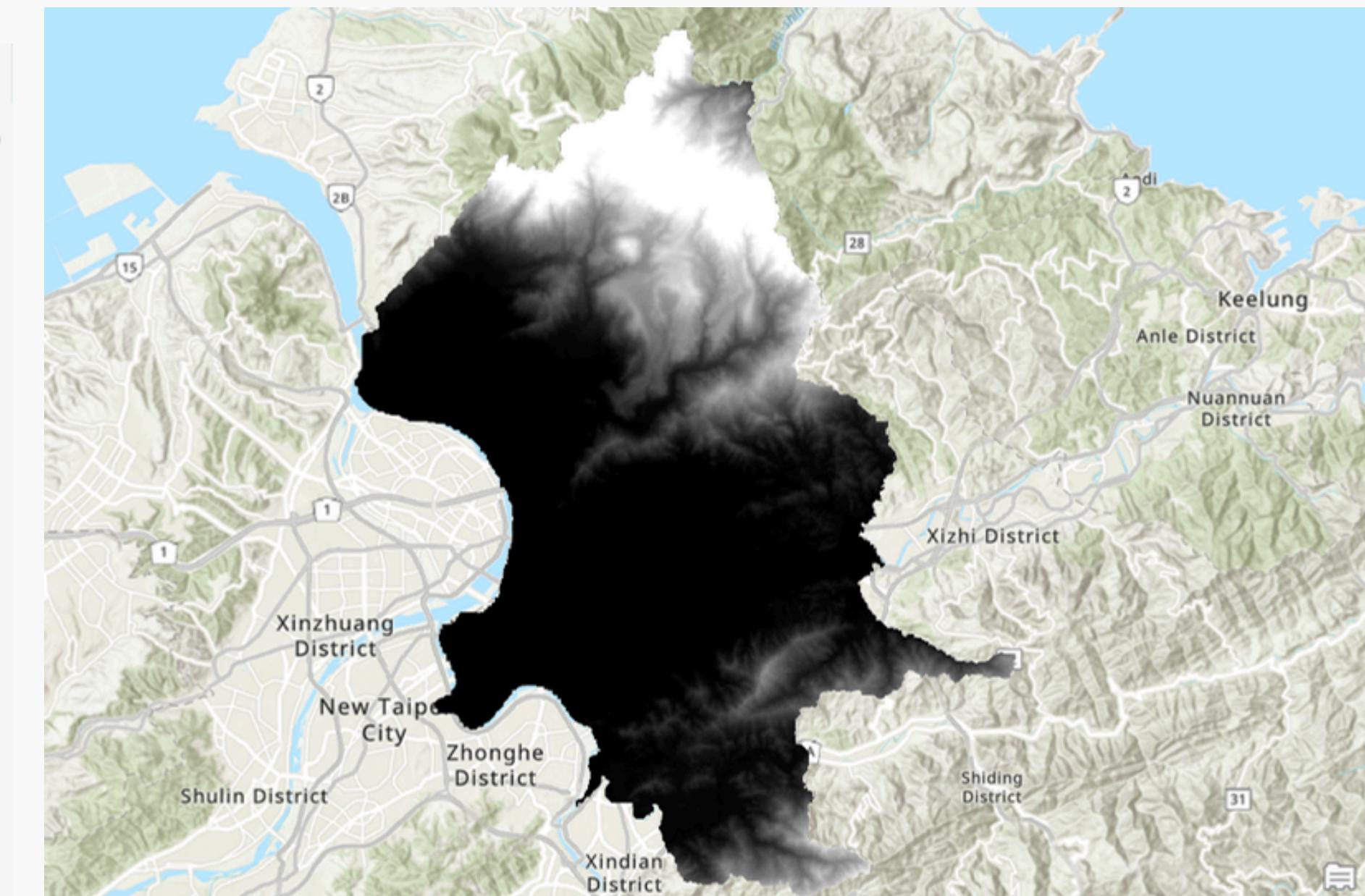
Operators

- +
-
- *
- /

"tpe_dtm.tif" * "Reclass_tpe_1"

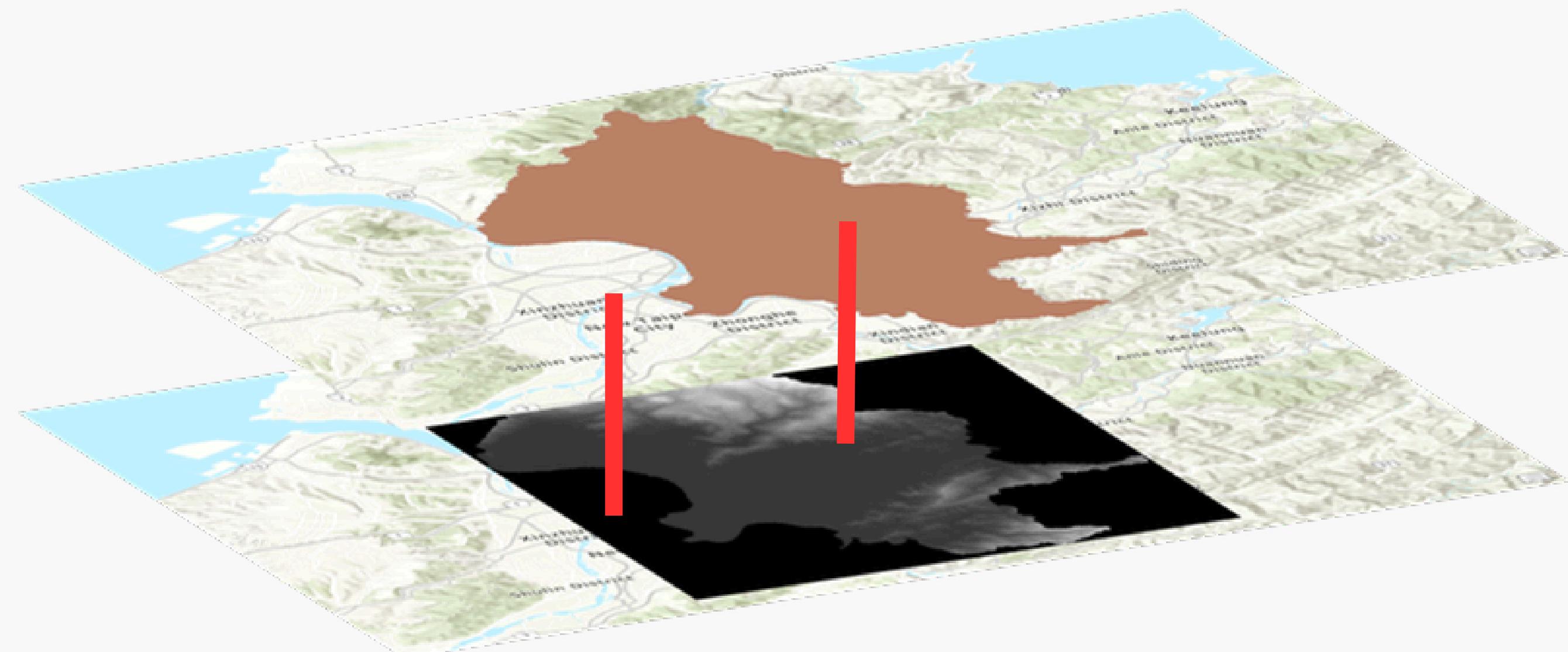
Output raster

RasterC_1



Flooding Potential Area

■ Preprocessing - Raster Calculator



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Flooding Potential Area

Raster to Point

Geoprocessing



Raster to Point



Parameters Environments

Input raster

RasterC_1



Field

Value



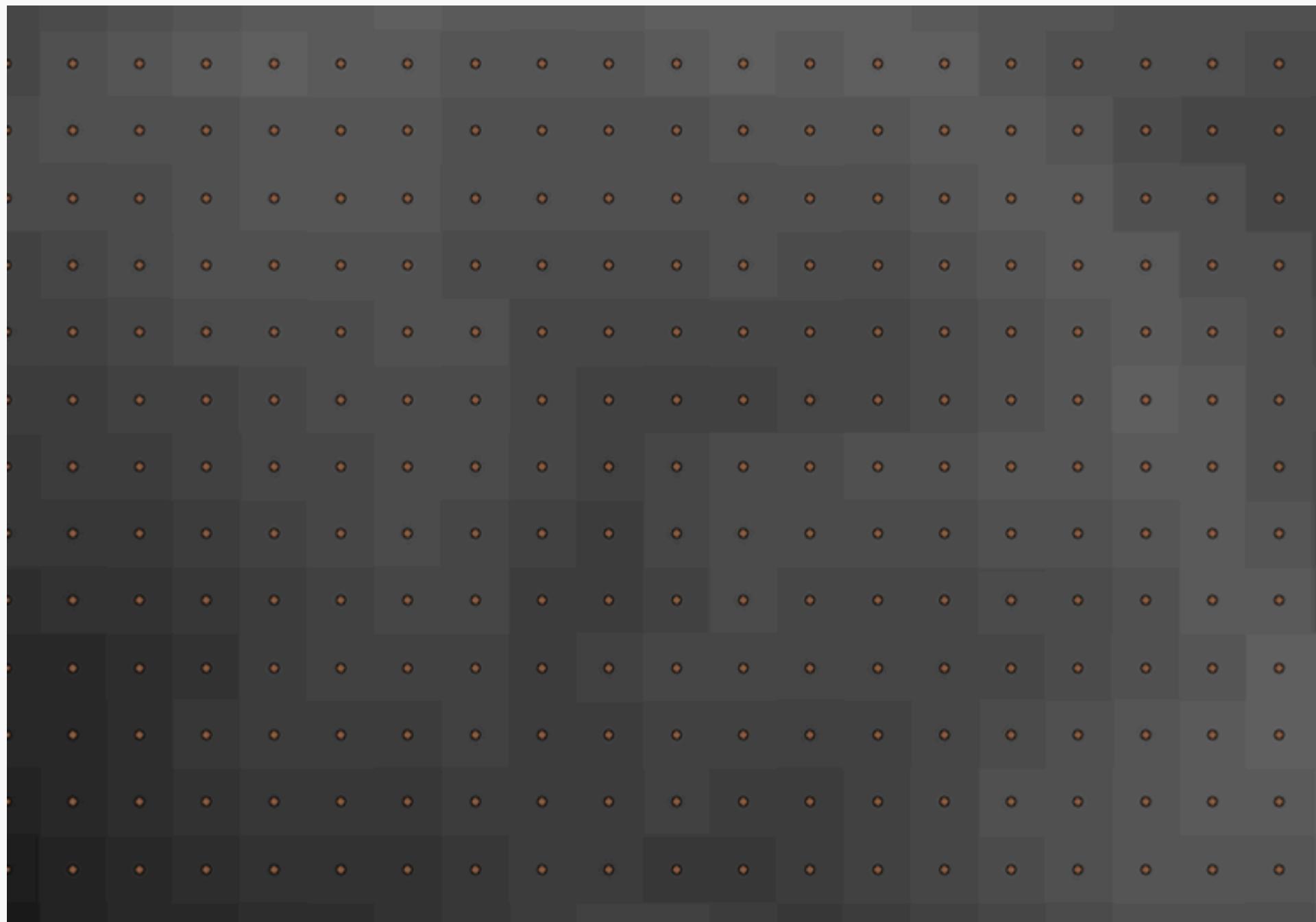
Output point features

RasterT_RasterC1



Flooding Potential Area

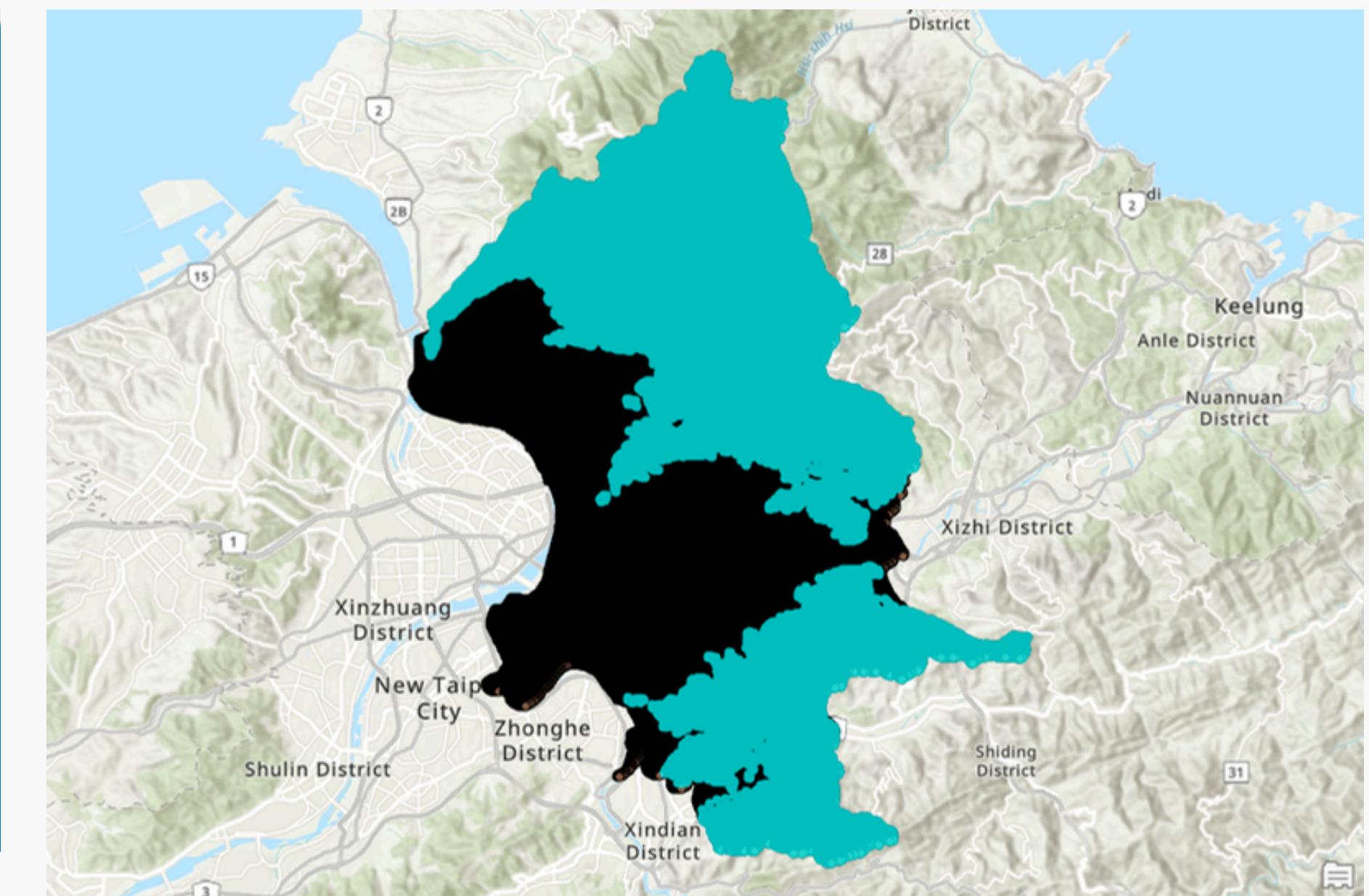
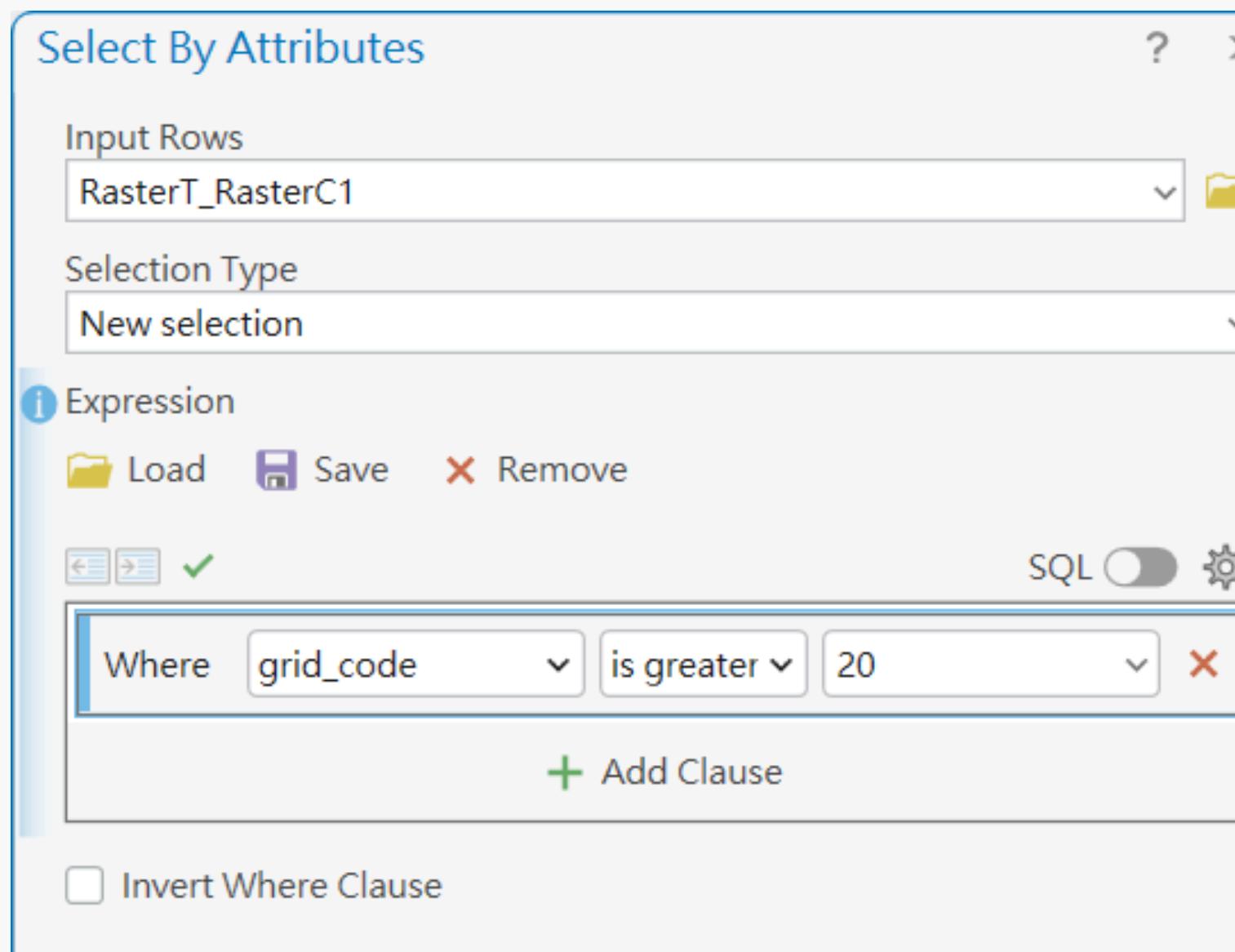
Raster to Point



RasterT_RasterC1				
Field:		Add	Calculate	Selection:
OBJECTID *	Shape *	pointid	grid_code	
1	1	Point	1	1036
2	2	Point	2	1029
3	3	Point	3	1034
4	4	Point	4	1034
5	5	Point	5	1016
6	6	Point	6	983
7	7	Point	7	974
8	8	Point	8	989

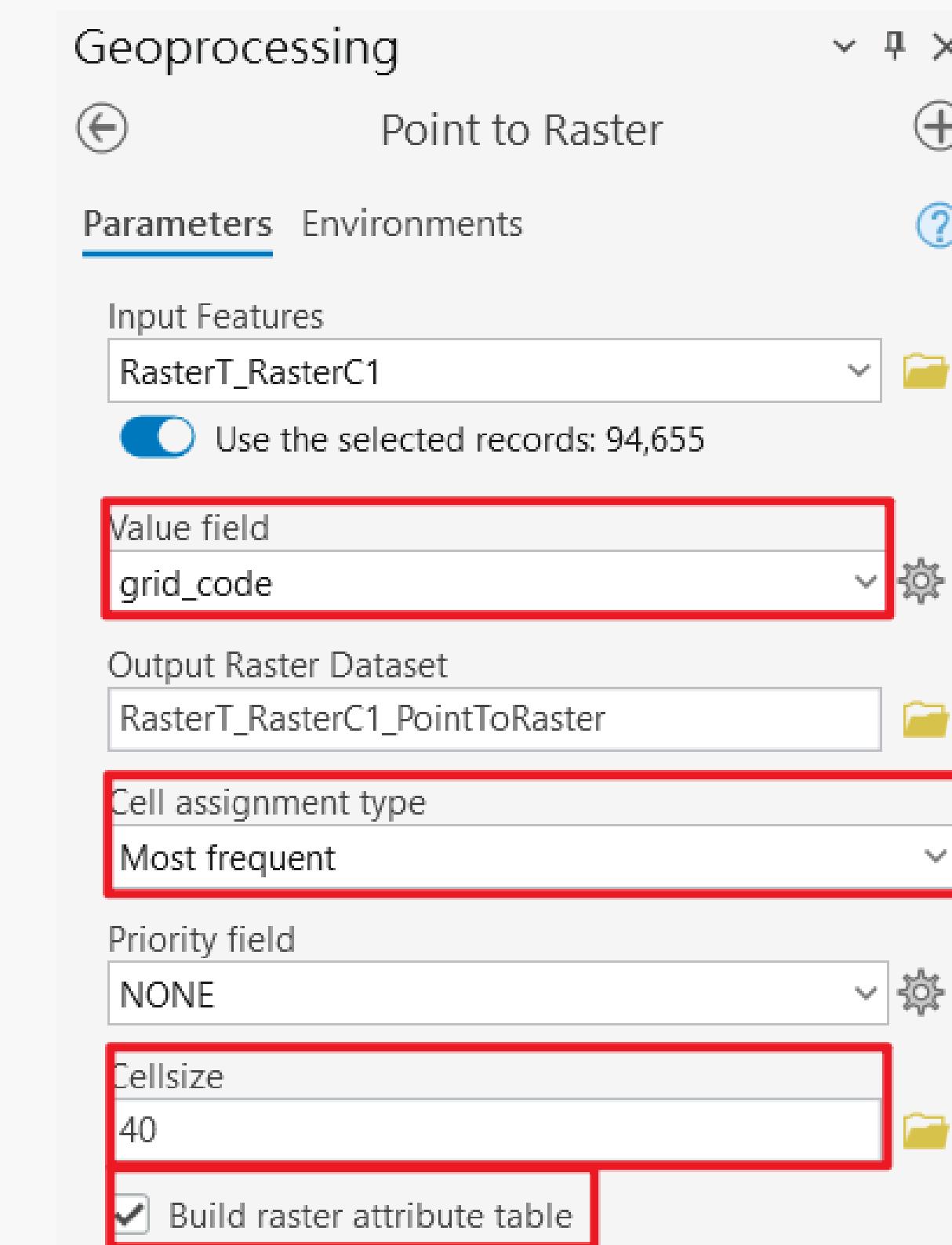
Flooding Potential Area

■ Select by Attribute => height above 20m



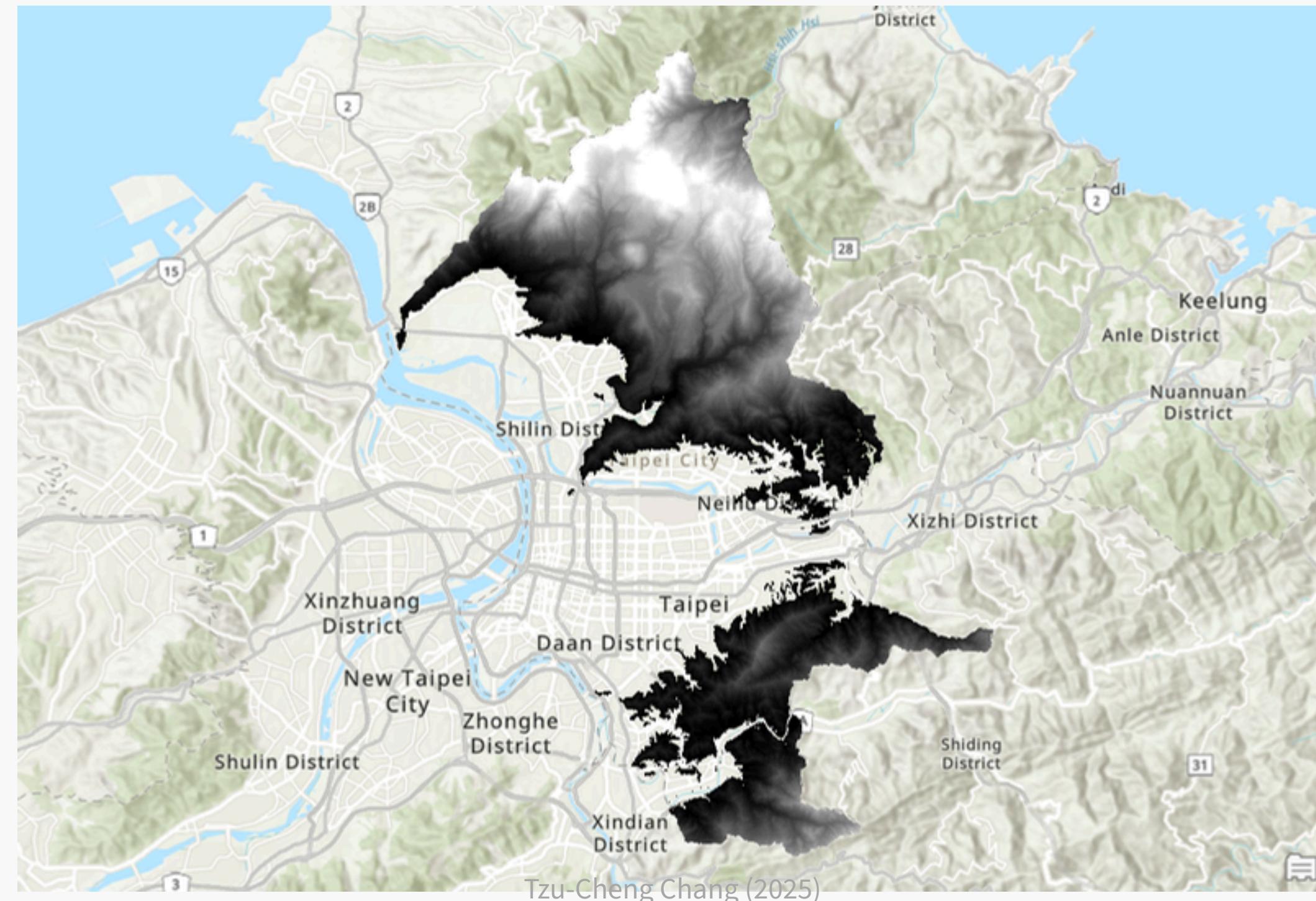
Flooding Potential Area

Point to Raster



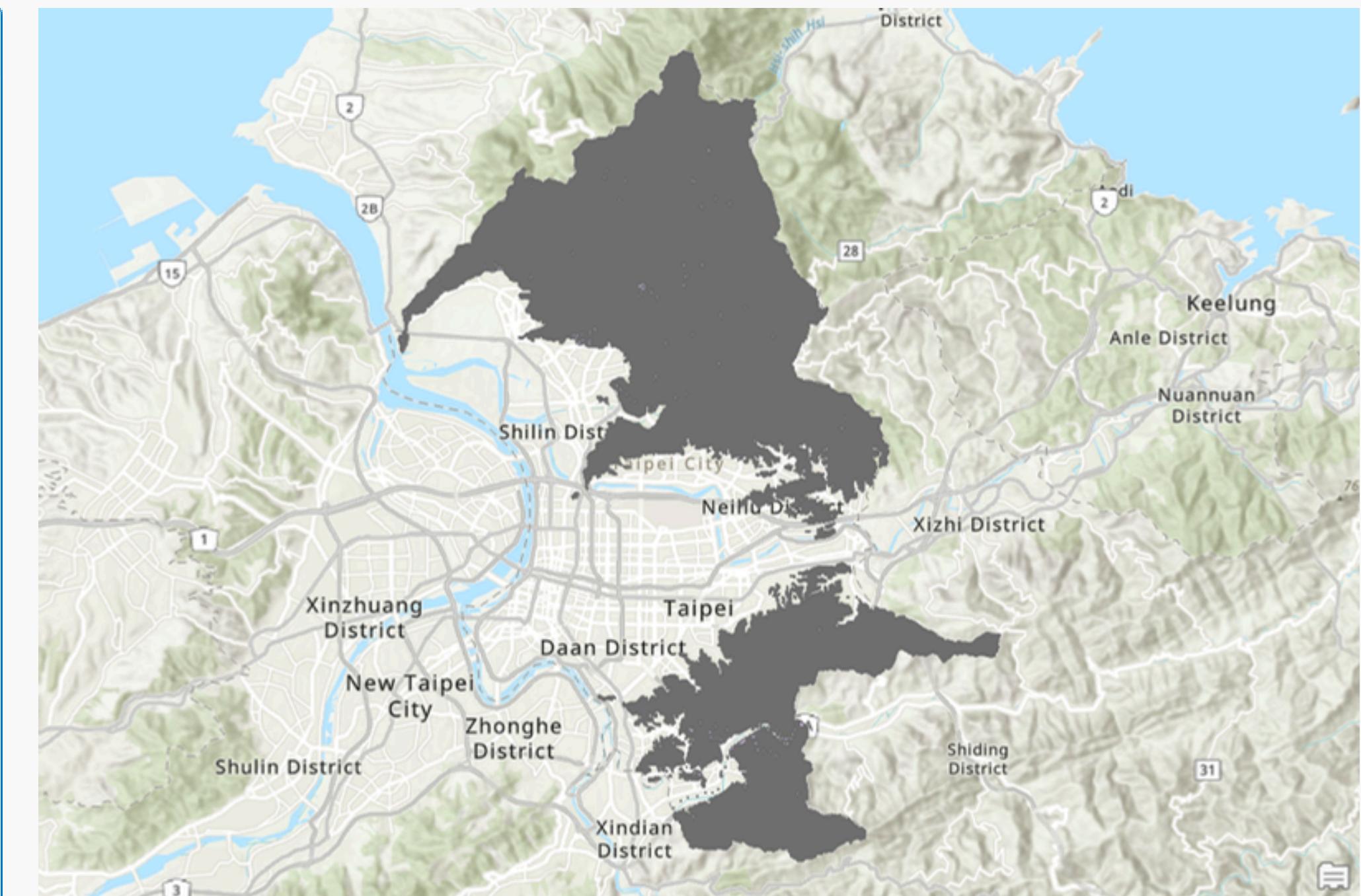
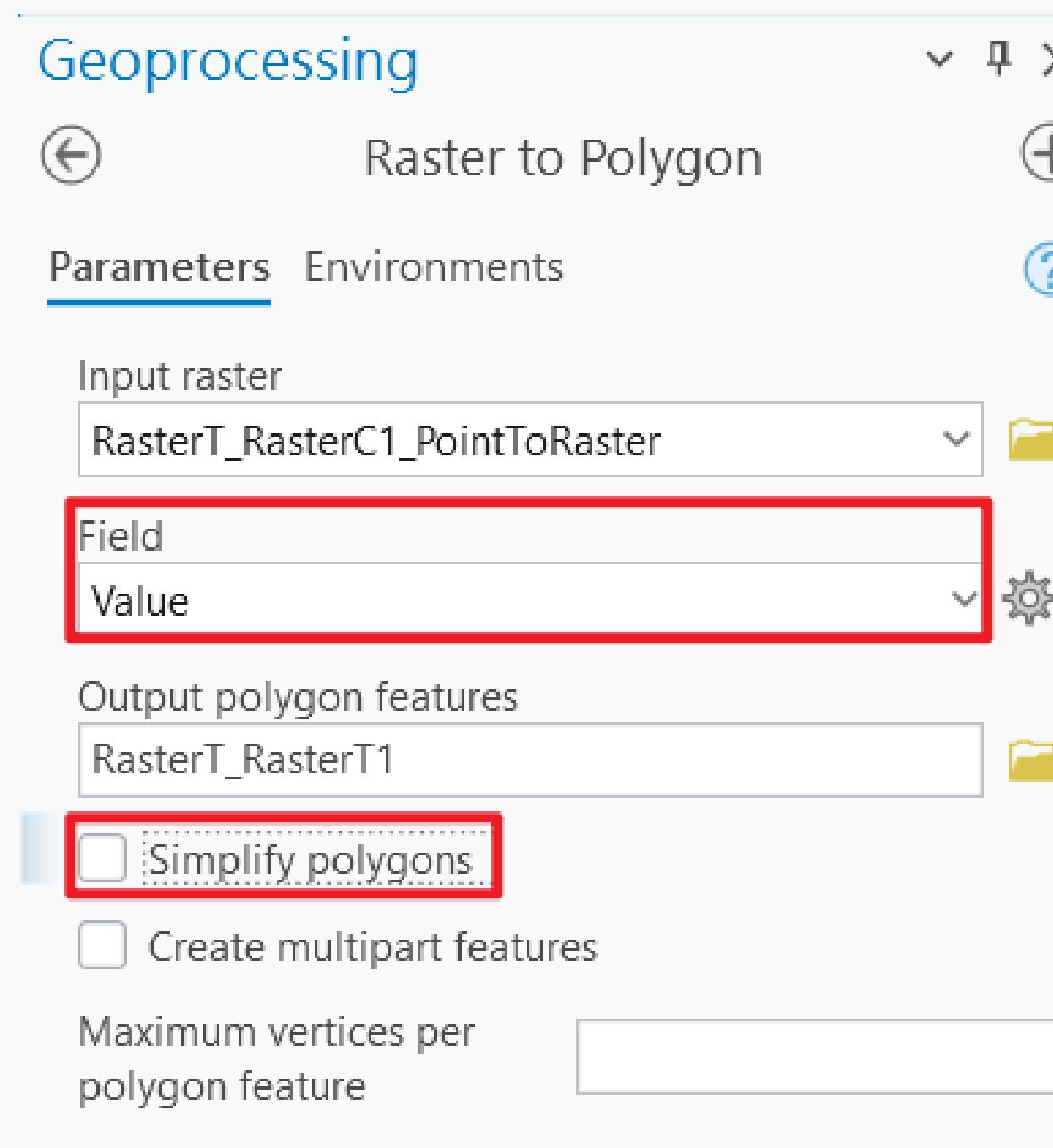
Flooding Potential Area

■ Point to Raster



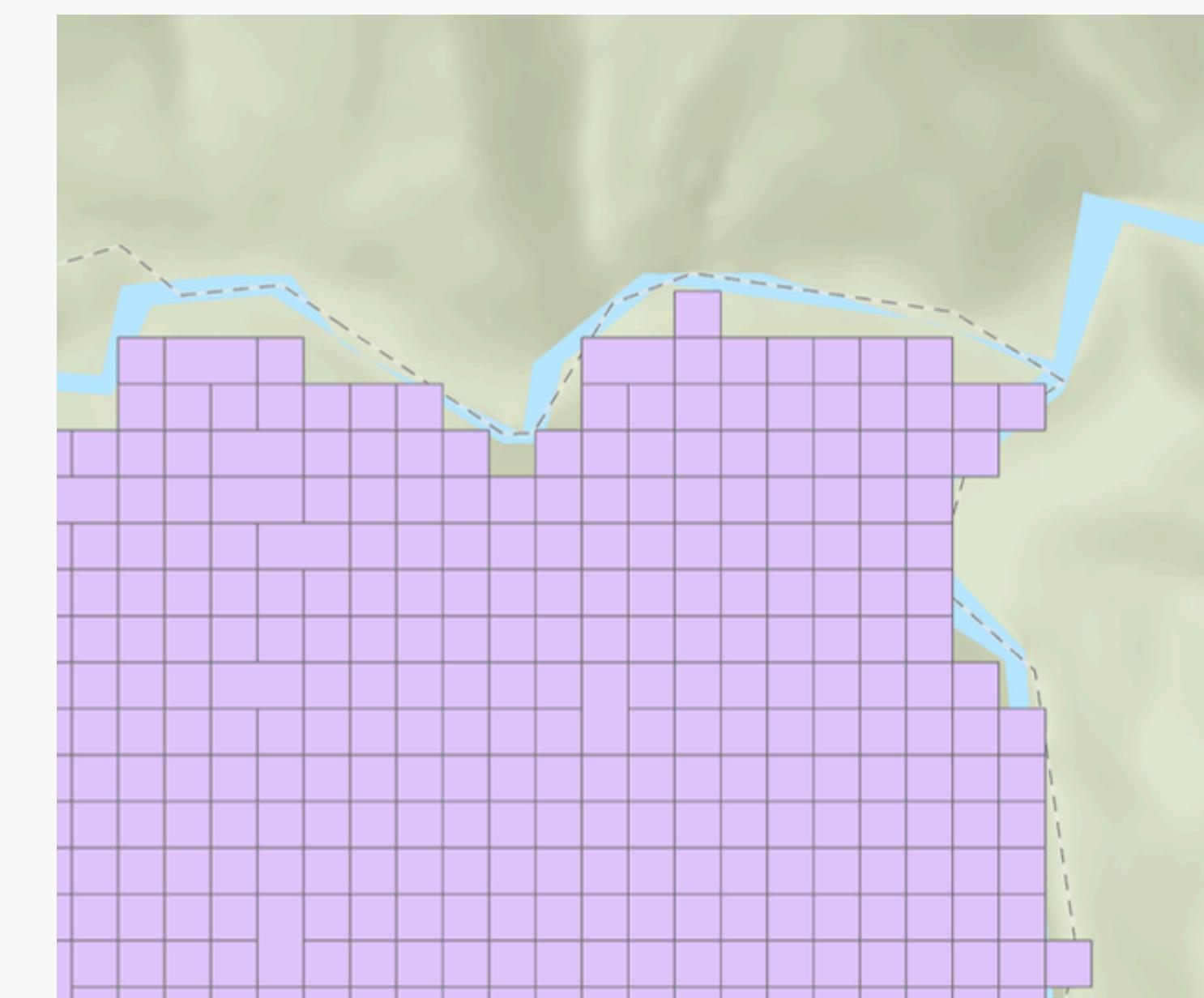
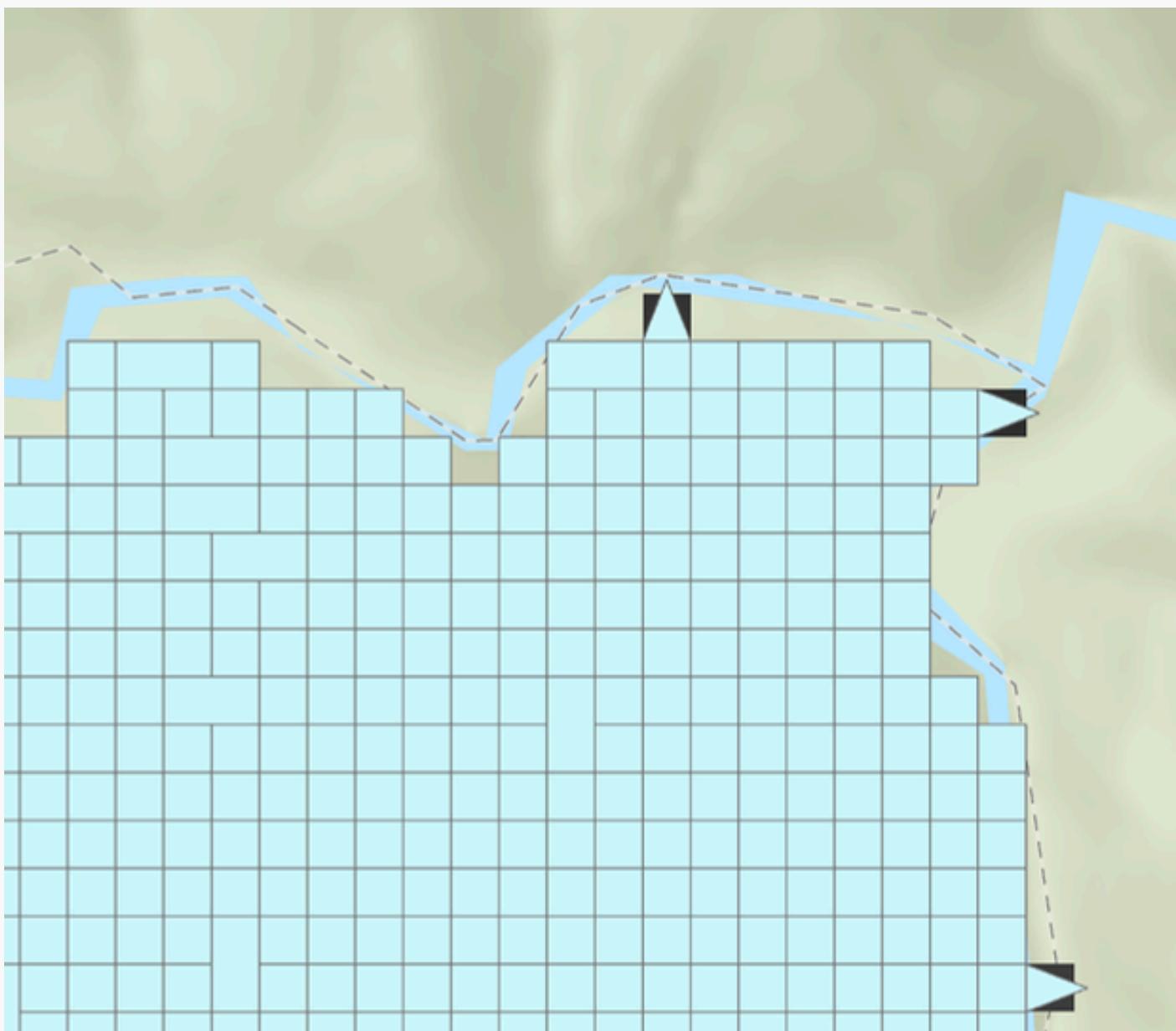
Flooding Potential Area

Raster to Polygon



Flooding Potential Area

■ Raster to Polygon



Flooding Potential Area

- Lab Practice I - Calculate total non-affected population with 20m height flooding area.

intersect => calculate area & pop ($P_DEN * area / 1000000$) => dissolve

Plants Cover Estimation (NDVI)

■ Lab Practice II - Find the area that NDVI value greater than 0.4 .

Using the Point, Polygon and Raster convention to extract the target area.

After selecting NDVI point above 0.4, you will use point to raster make it a raster layer. To get the area in total, we need to transfer the raster into polygon.

Use Raster Domain to convert it into Polygon.

Notice the **Cell size**.

Plants Cover Estimation (NDVI)

- Composite the bands.
- Extract by Mask
- Using Symbology to Make False Color Imagery.
 - Symbology - Stretch Type
 - Statistics
- Raster Calculator

Plants Cover Estimation (NDVI)

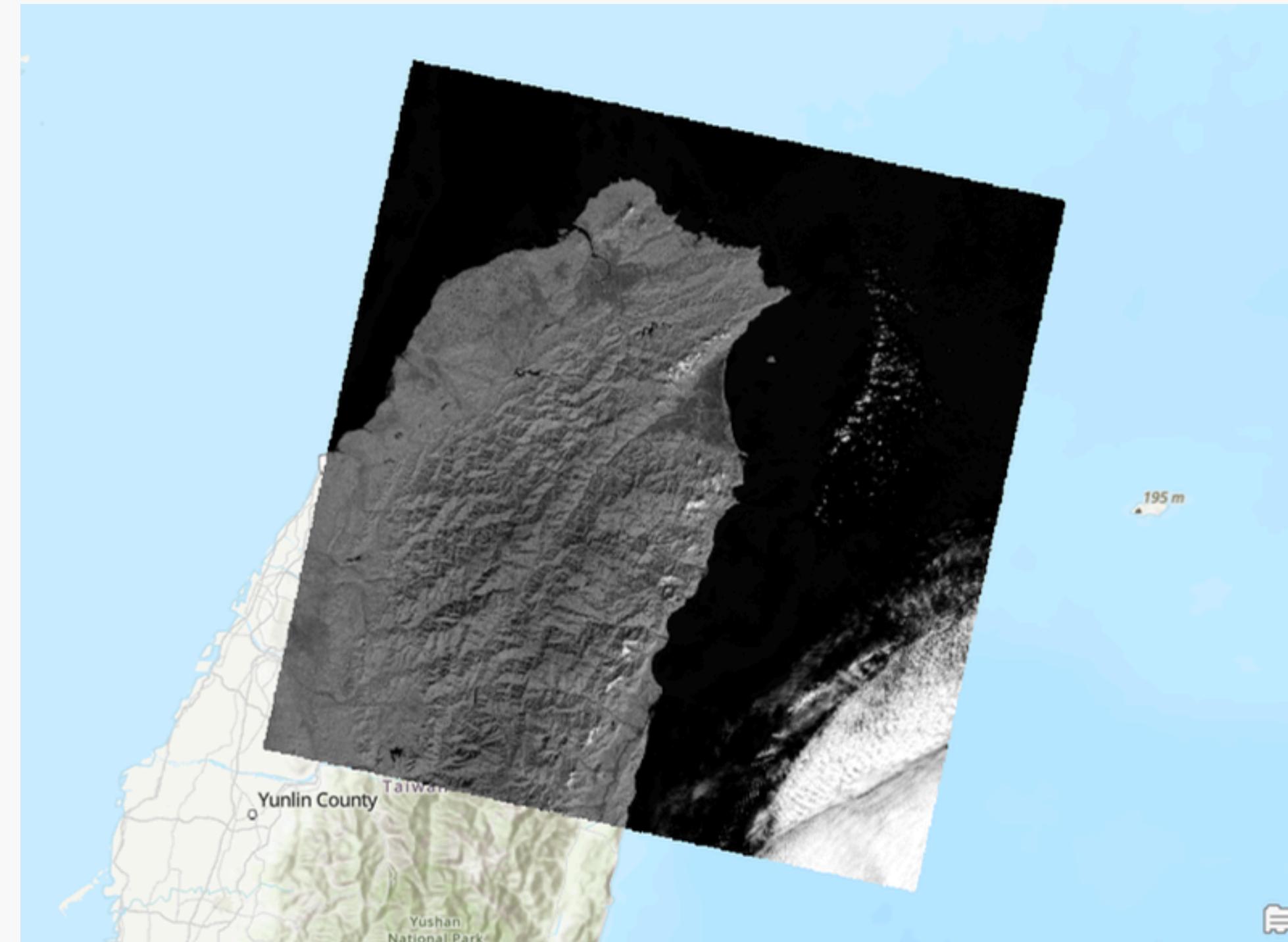
■ Composite the bands.

The screenshot shows a QGIS catalog interface. On the left, there is a tree view of project contents under 'Project'. The 'Raster_try2' folder is expanded, showing several sub-folders and files. One folder, 'LC08_L2SP_117043_20231208_20231214_02_T1', contains five files: 'LC08_L2SP_117043_20231208_20231214_02_T1_SR_B2.TIF', 'LC08_L2SP_117043_20231208_20231214_02_T1_SR_B3.TIF', 'LC08_L2SP_117043_20231208_20231214_02_T1_SR_B4.TIF', 'LC08_L2SP_117043_20231208_20231214_02_T1_SR_B5.TIF', and 'tpe_dtm'. These four files are highlighted with a red box. Below them are 'tpe_dtm' and 'TPE_Village'. At the bottom is a file named '113年6月行政區人口統計_村里_臺北市.csv'. On the right, a table provides details for each band, including its name, Landsat-8 OLI band, center wavelength, and spatial resolution.

Channel	Landsat-8 OLI band (nms)	Center wavelength (nms)	Spatial (m)
Coastal/Aerosol	Band 1 (433–453)	443	30
Blue	Band 2 (450–515)	483	30
Green	Band 3 (525–600)	560	30
Red	Band 4 (630–680)	660	30
NIR	Band 5 (845–885)	865	30
SWIR 1	Band 6 (1560–1660)	1650	30
SWIR2	Band 7 (2100–2300)	2220	30
Panchromatic	Band 8 (500–680)	640	15
Cirrus	Band 9 (1360–1390)	1375	30

Plants Cover Estimation (NDVI)

- Composite the bands.



Plants Cover Estimation (NDVI)

Composite the bands.

Geoprocessing

Composite Bands

Parameters Environments

Input Rasters

- R LC08_L2SP_117043_20231208_20231214_02_T1_SR_B4.TIF
- G LC08_L2SP_117043_20231208_20231214_02_T1_SR_B3.TIF
- B LC08_L2SP_117043_20231208_20231214_02_T1_SR_B2.TIF
- NIR LC08_L2SP_117043_20231208_20231214_02_T1_SR_B5.TIF

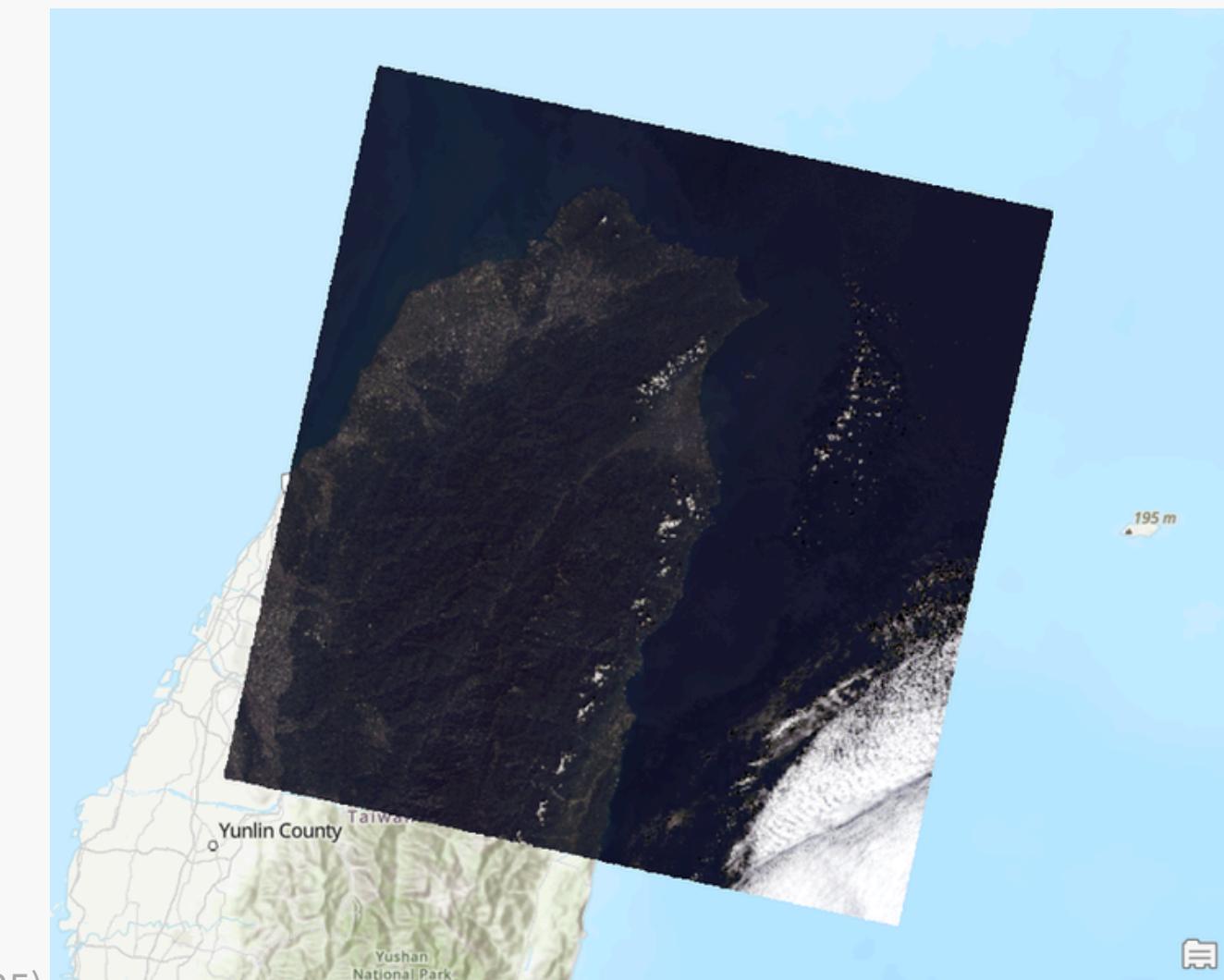
Output Raster

LC08_L2SP_1170_CompositeBand1

LC08_L2SP_1170_CompositeBand

RGB

- Red: Band_1
- Green: Band_2
- Blue: Band_3



Tzu-Cheng Chang (2025)

Plants Cover Estimation (NDVI)

Extract by Mask

Geoprocessing

Extract by Mask

Parameters Environments

Input raster
LC08_L2SP_1170_CompositeBand

Input raster or feature mask data
TPE_Village

Output raster
Extract_LC081

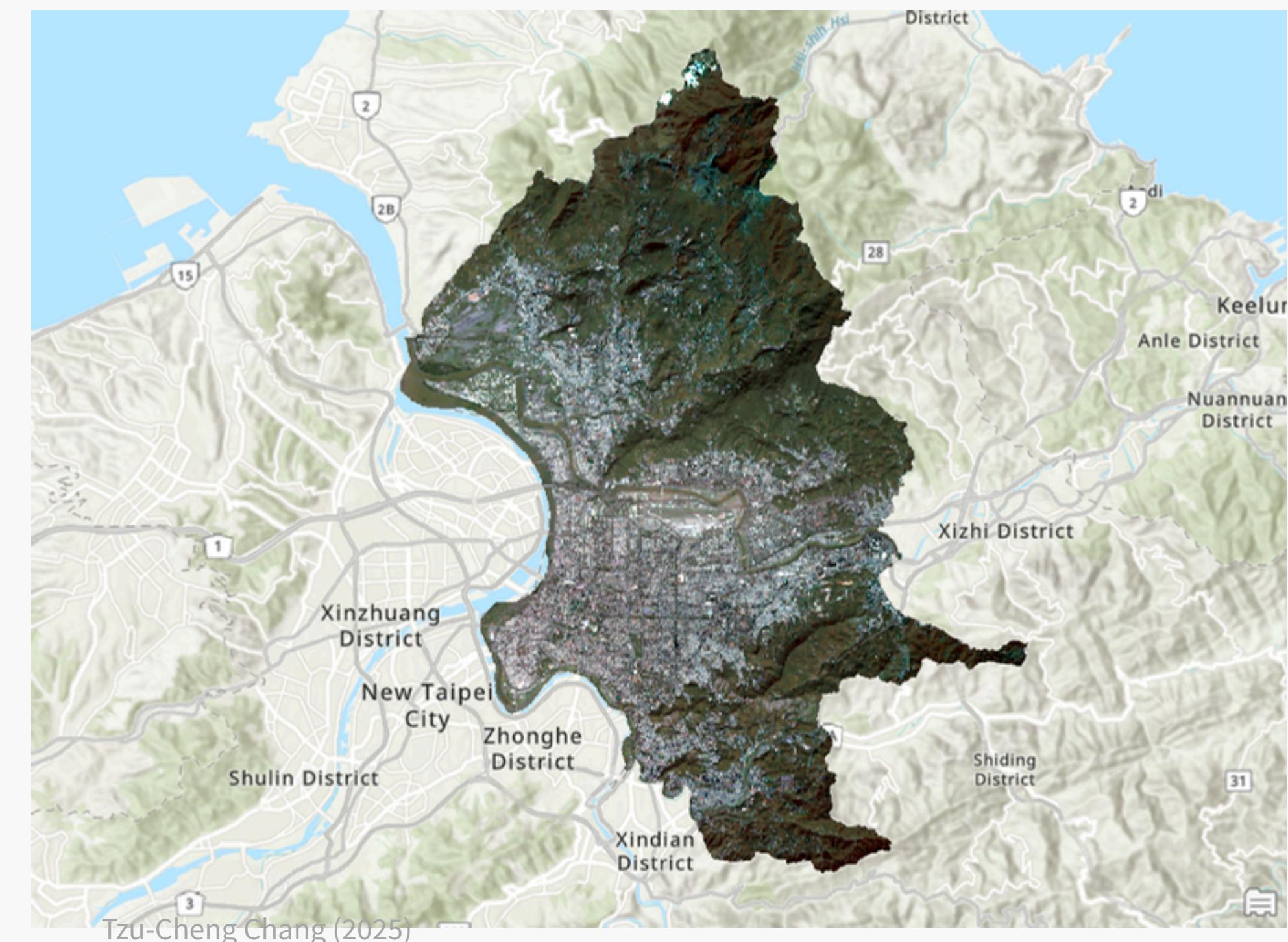
Extraction Area
Inside

Analysis Extent

X and Y Extent

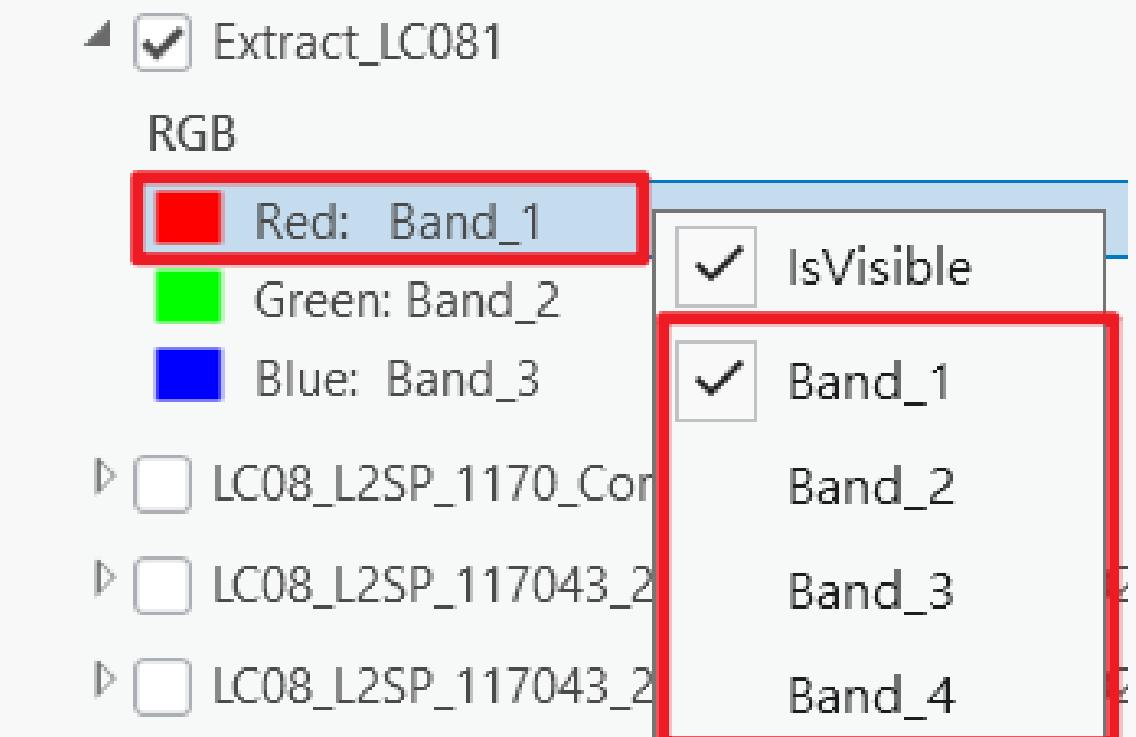
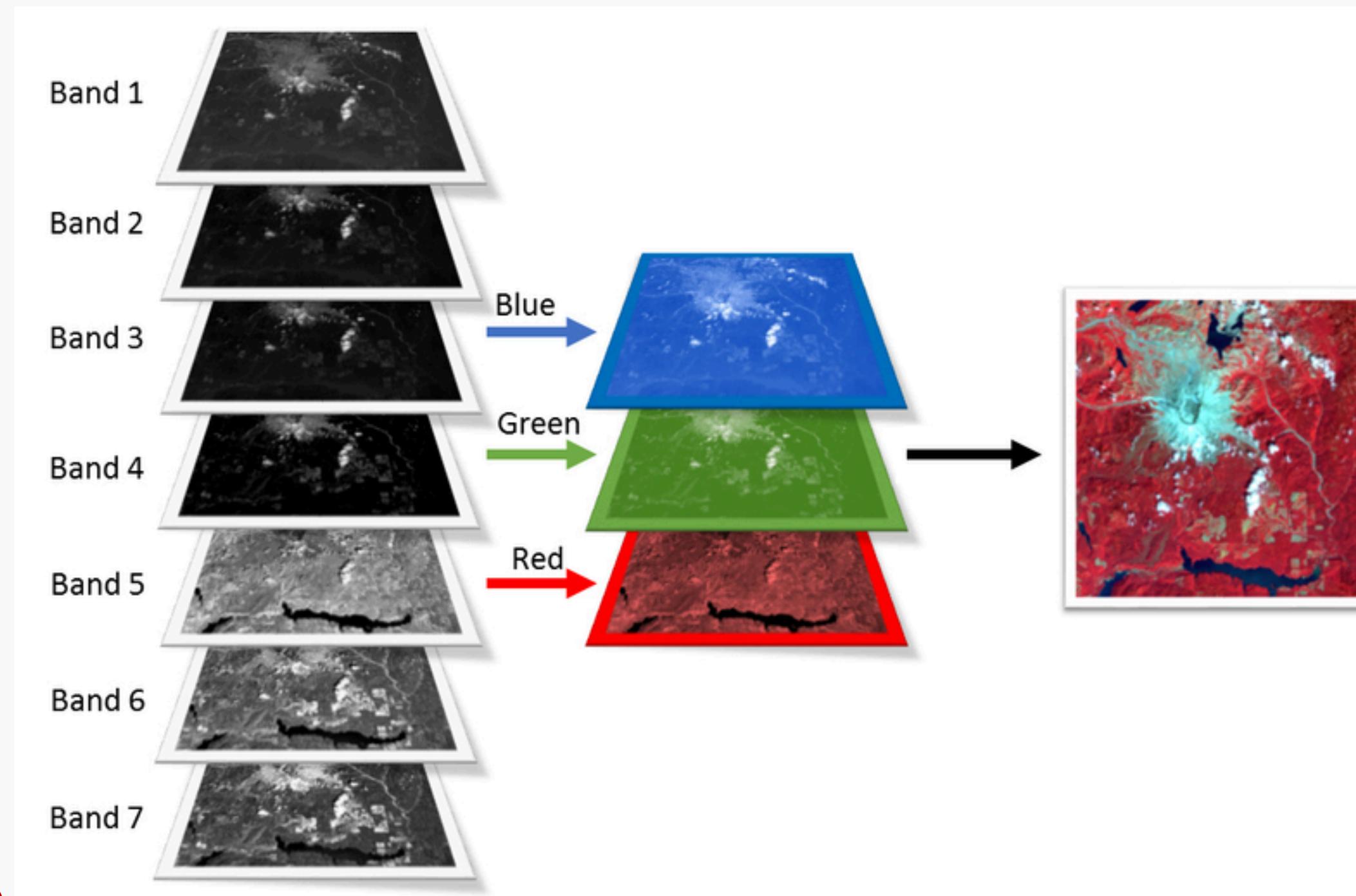
Top: 2789150.23229249
Left: 344195.025331714
Right: 365700.555814785
Bottom: 2761203.98190393

Extent Coordinate System
WGS 1984 UTM Zone 51N



Plants Cover Estimation (NDVI)

True Color vs. False Color



Plants Cover Estimation (NDVI)

■ True Color vs. False Color



True Color



False Color

Plants Cover Estimation (NDVI)

Raster Symbology

Symbology - Extract_LC081

Primary symbology: RGB

Red: Band_1, Green: Band_2, Blue: Band_3, Alpha: None

Invert:

Stretch type: Percent Clip (highlighted with a red box)

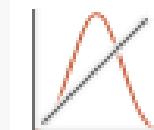
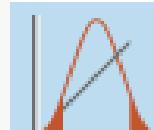
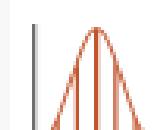
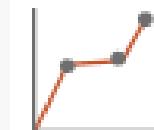
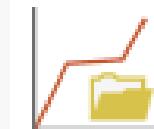
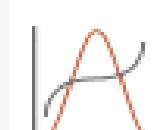
Min: 0.250, Max: 0.250

Gamma: 1.6

Statistics: Dataset (highlighted with a red box)

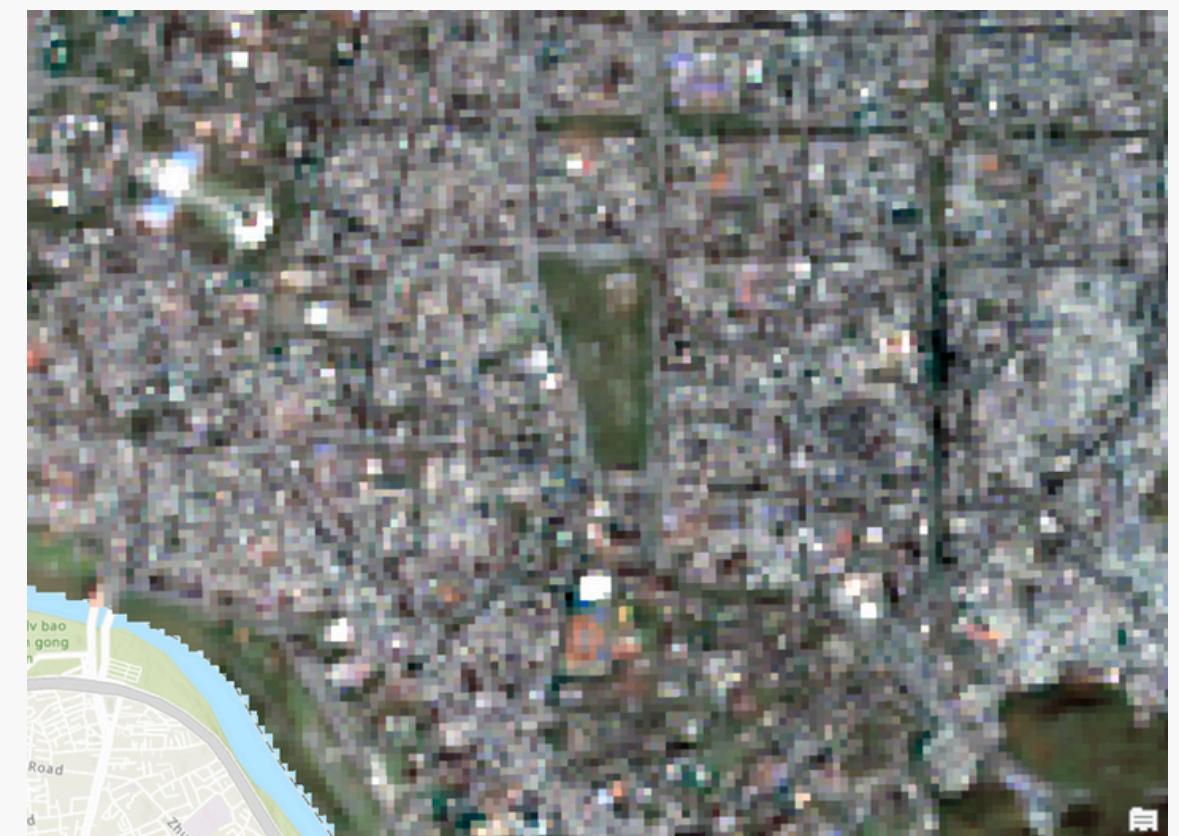
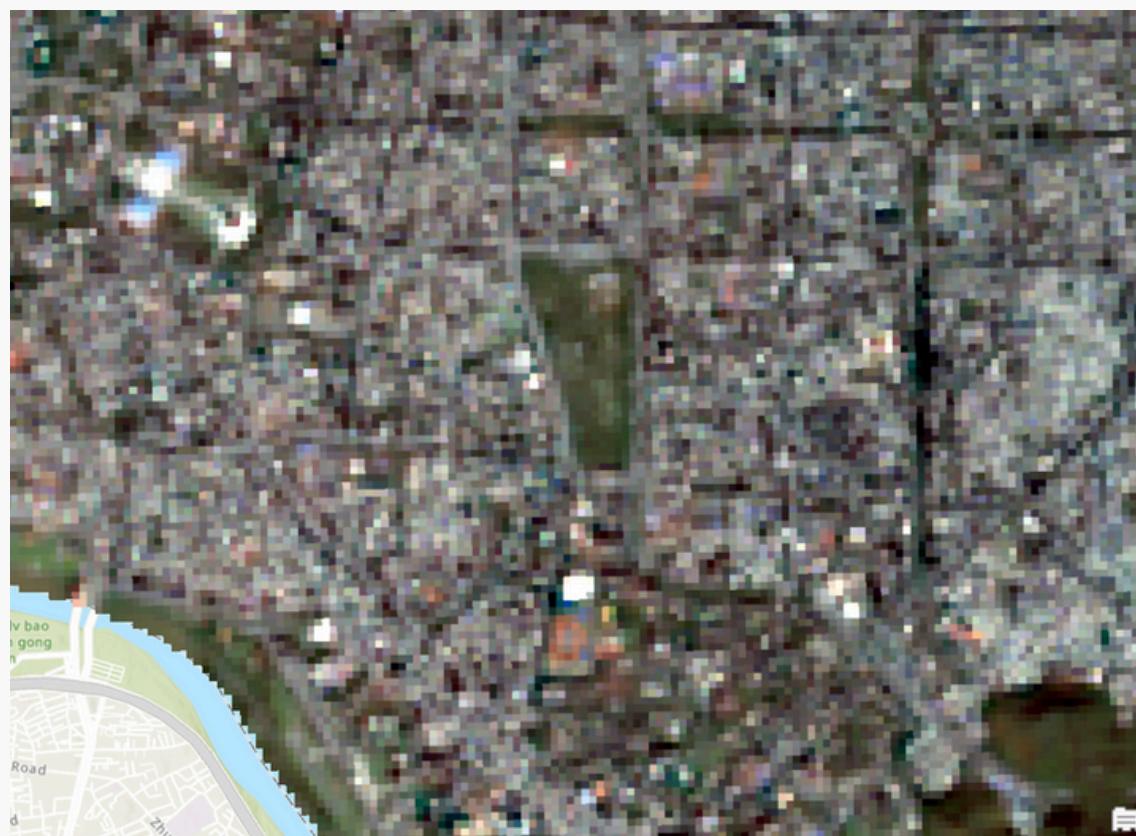
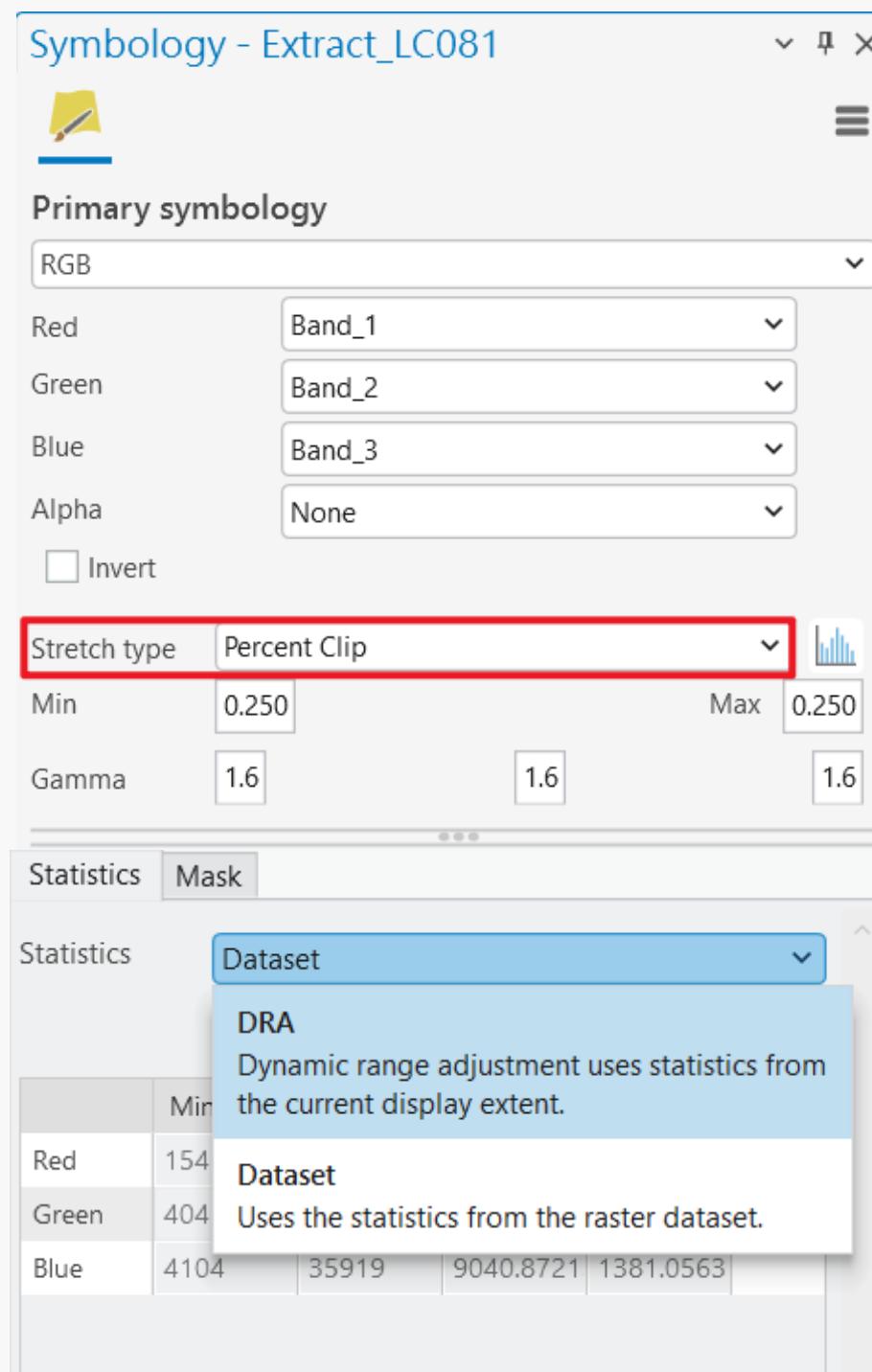
	Min	Max	Mean	Std. dev
Red	154	33993	8544.3531	958.14689
Green	4045	34366	9332.6469	1125.7800
Blue	4104	35919	9040.8721	1381.0563

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-  **Minimum Maximum**
Display values between the actual minimum and maximum.
-  **Percent Clip**
Cut off percentages of highest and lowest values.
-  **Standard Deviation**
Display values between a specified number of standard deviations.
-  **Histogram Equalize**
Display values with histogram equalize
-  **Custom**
Display values with custom histogram.
-  **Histogram Specification**
Display values with histogram specification
-  **Esri**
Highlight the contrast of moderate values while minimizing the impact of extreme high and low values.

Plants Cover Estimation (NDVI)

Raster Symbology



DRA

Adjust from view scale.

Dataset

Statistic for all dataset.

Plants Cover Estimation (NDVI)

■ Raster Calculator

In NDVI, we need Red band and NIR band.

After our operation of composite bands,
band1 represents Red band,
band4 represents NIR band.

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

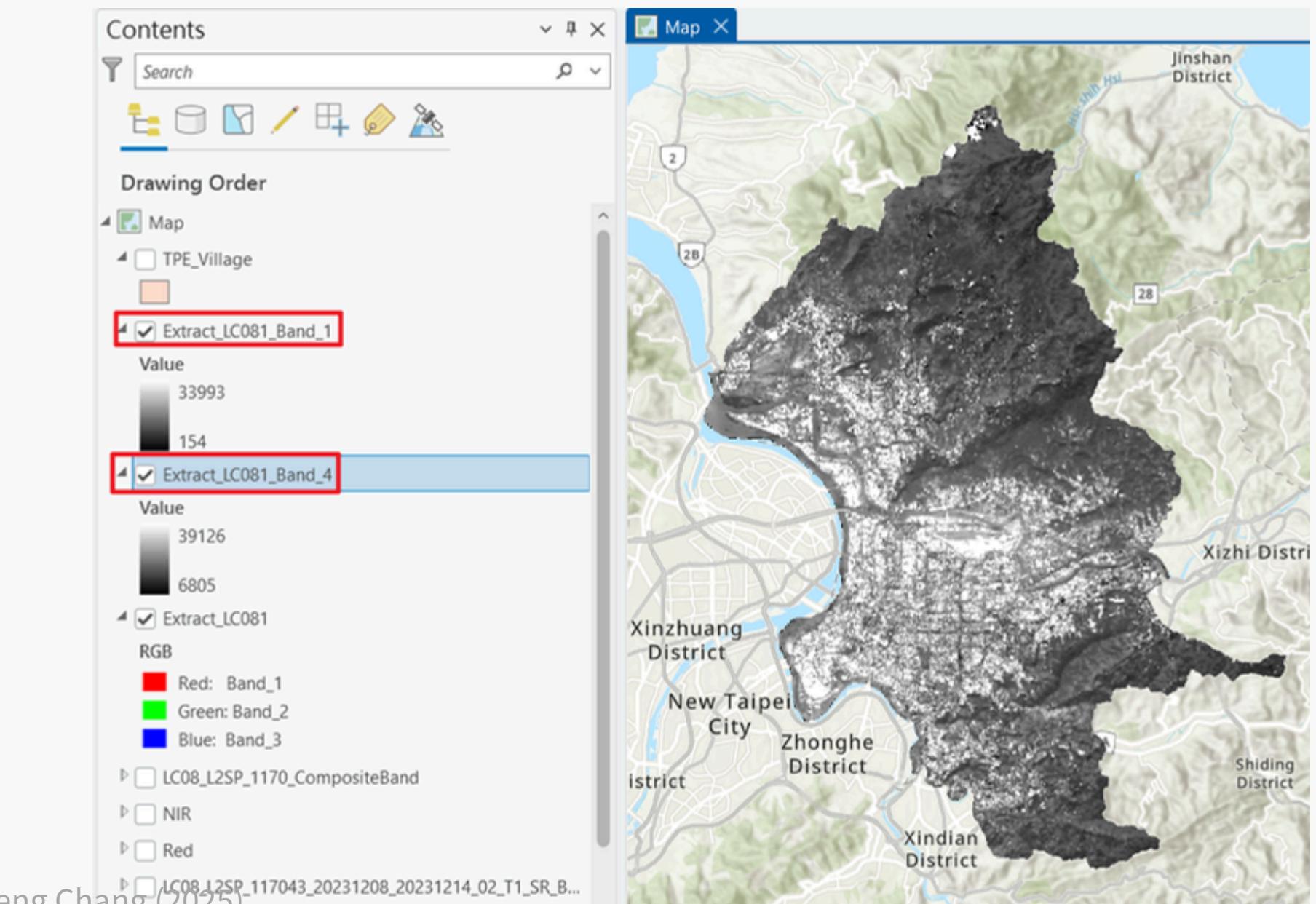
Plants Cover Estimation (NDVI)

Raster Calculator

Add single band from geodatabase.



$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$



Plants Cover Estimation (NDVI)

Raster Calculator

Geoprocessing

Raster Calculator

Parameters Environments

Map Algebra expression

Rasters

- LC08_L2SP_1170_CompositeBand
- Extract_LC081_Band_5
- Extract_LC081_Band_4
- LC08_L2SP_117043_20231208_20
- LC08_L2SP_117043_20231208_20

("Extract_LC081_Band_5" - "Extract_LC081_Band_4") / ("Extract_LC081_Band_5" + "Extract_LC081_Band_4")

Output raster

RasterC_3

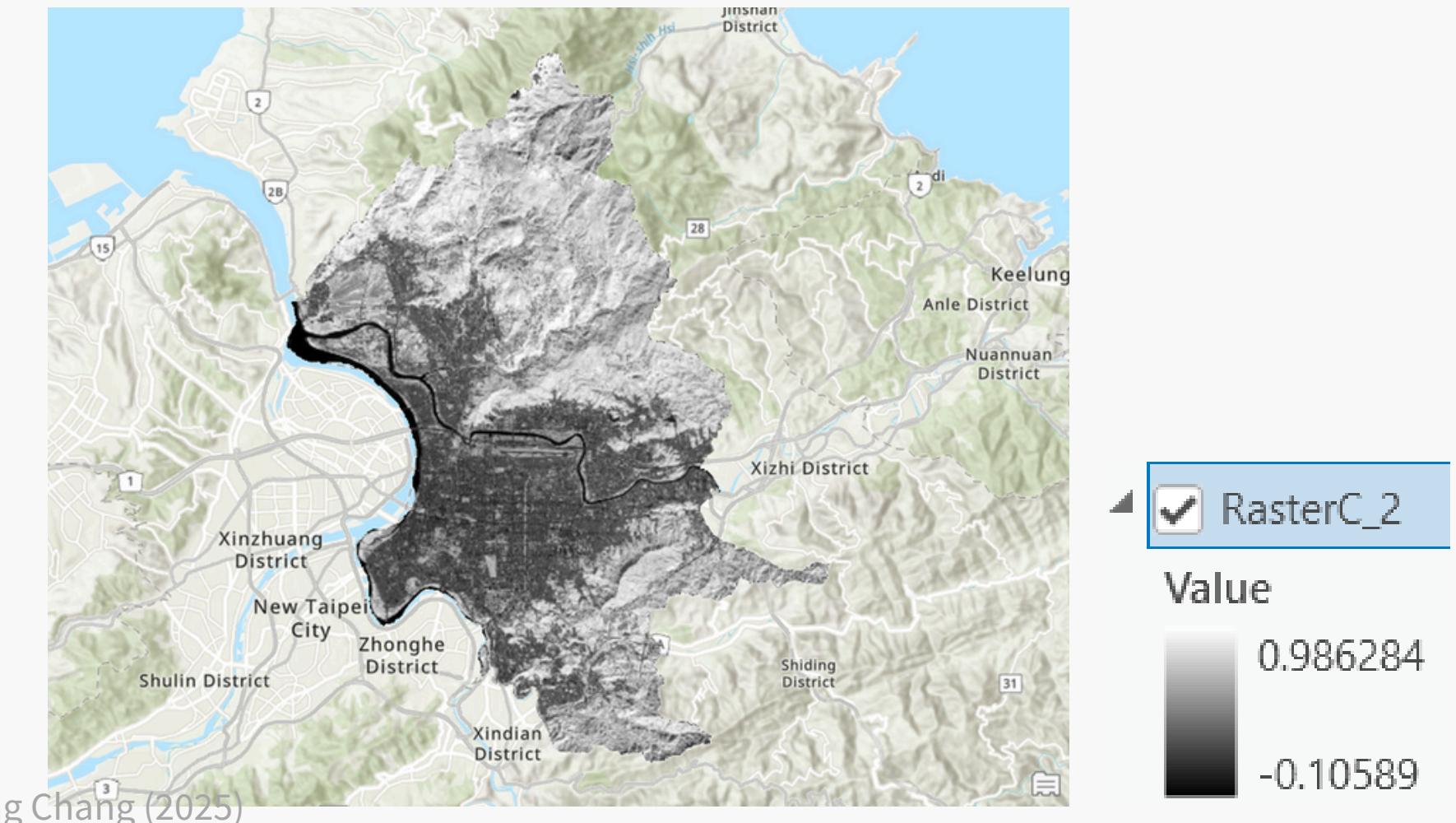
Tools

Operators

- +
-
- *
- /

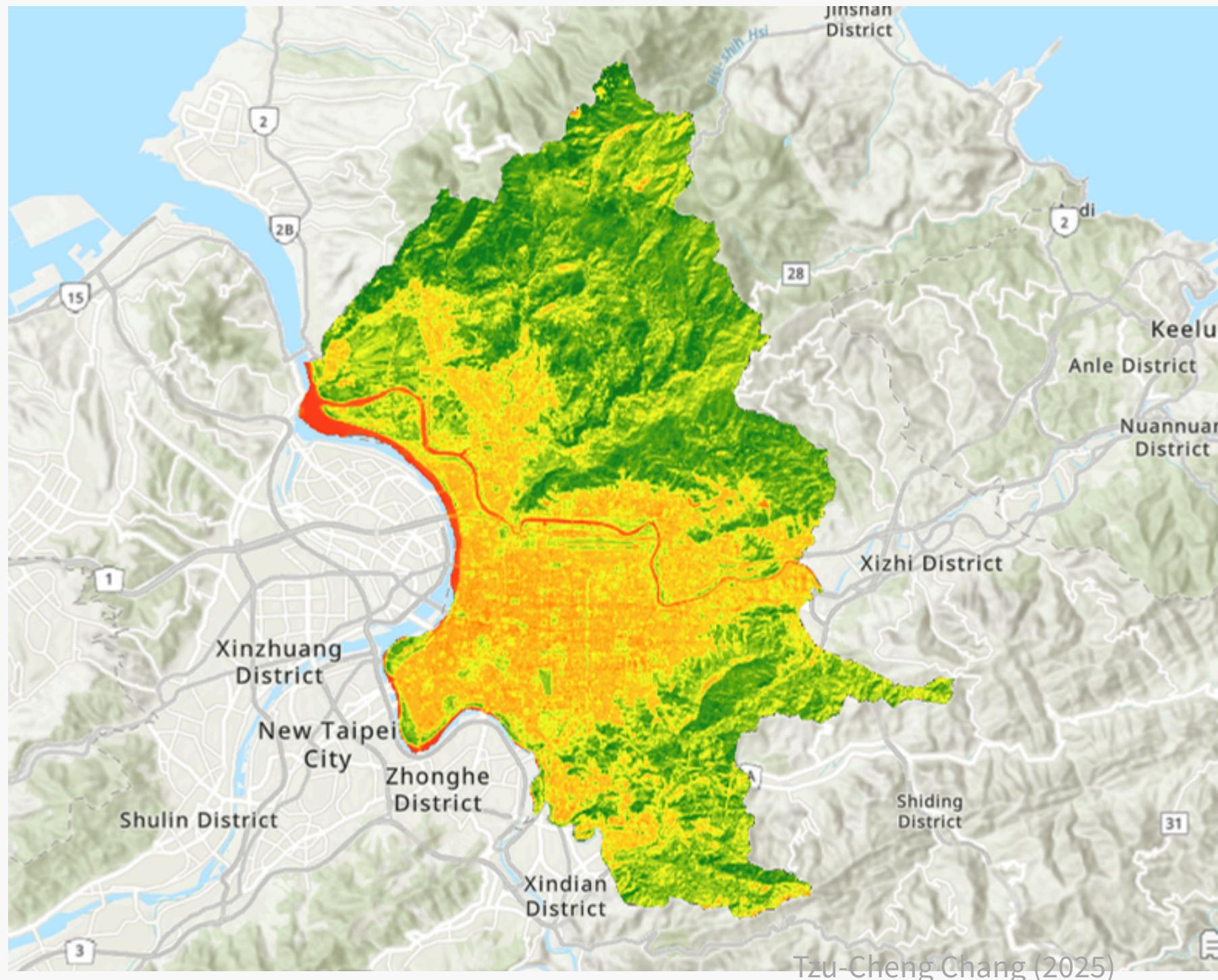
$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

Value range: -1 ~ 1



Plants Cover Estimation (NDVI)

■ Raster Calculator



With symbology adjustment

Plants Cover Estimation (NDVI)

Geoprocessing

Point to Raster



Tzu-Cheng Chang (2025)

Point to Raster

Parameters Environments

Input Features

RasterT_RasterC1

Use the selected records: 53,546

Value field

grid_code

Output Raster Dataset

RasterT_RasterC1_PointToRaster

Cell assignment type

Mean

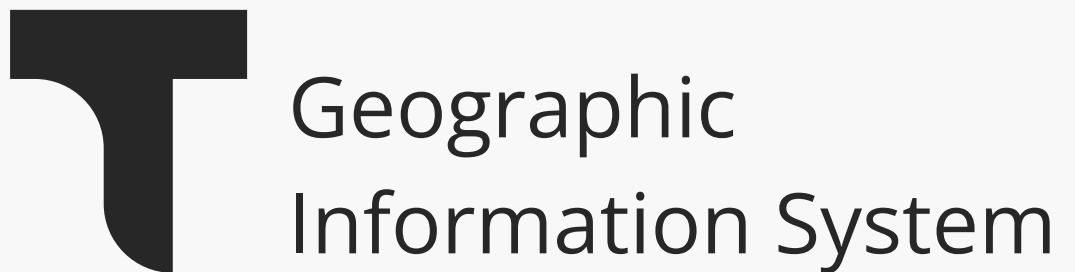
Priority field

NONE

Cellsize

30

Build raster attribute table



Thank You

05 DEC, 2025